Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 17
SEPT. 1944
No. 9

INCLUDING

Aviation Instruments

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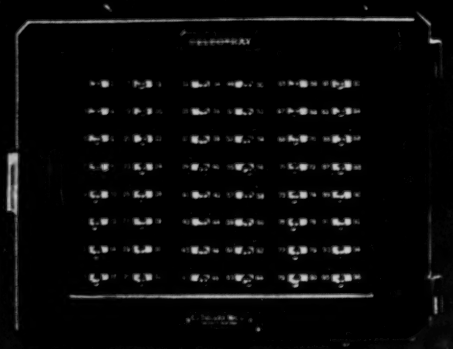
INDICATING CONTROLLER



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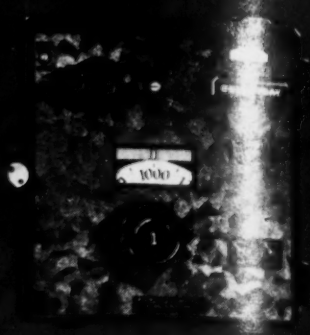

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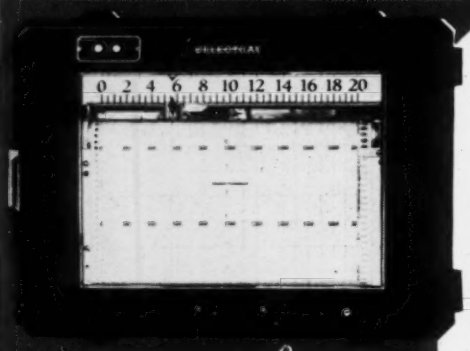

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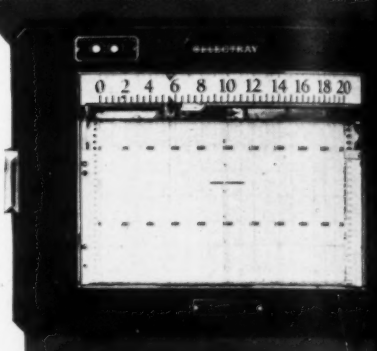

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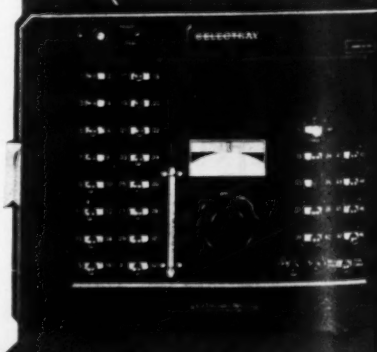

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

"Instrumentation Comes of Age"

PERHAPS I indulged in wishful thinking the first time I used this expression (six years ago?) but now I assert that Instrumentation HAS come of age as a profession. My *assertion* will not startle you but the FACTS with which I can back it up affect your bread-and-butter. A systematic array of all these facts would fill a book. Meanwhile, a few items of live news value are presented below, following a correlative editorial introduction.

1. EDUCATION—*(a) Universities:* Ten or more join this autumn the list of those giving instrument courses. Four news items are appended (two from GWU alone!).

(b) Instrument companies: Several have been giving courses in their factories. The latest news item from the Brown Instrument Co. is appended. [By the way, orchids to Brown and to the Franklin Institute for the "Arts of Industrial Instrumentation" exhibit.]

(c) Other manufacturing companies: Several give courses on gages, electron tubes, etc., to their own employees, but the appended Westinghouse item announces that course material is available to *any* group anywhere.

2. SCIENTIFIC, ENGINEERING AND TECHNICAL SOCIETIES—*(a) Scientific Societies:* Measurement subjects are on the increase at sessions of physical, chemical and other purely scientific societies. The AAAS Research Conference on Instrumentation has become an annual fixture. The AIP has given "Instrumentation" a prominent place in an organizational chart published in the *Journal of Applied Physics.*

(b) Engineering societies: Our January issue in honor of the ASME was filled with instrumentation papers presented at *one* ASME meeting. Mere abstracts of all instrumentation papers at all meetings of all professional engineering societies in 1944 would fill several pages. Appended is a "sampling" of an AIEE meeting just concluded.

(c) Technical societies, etc.: Ernest Thum, Editor of *Metal Progress,* sends me an advance copy of his editorial on the prominence of the instrument sessions at the coming ASM meeting. An abstract is appended, as is an item on the National Electronics Conference, which also features instruments.

3. INSTRUMENT MEN'S SOCIETIES—*(a) American:* A glance at page 588 will disclose that their number has grown to seventeen (including Toronto: Canadians aren't "U.S.A." but they're brother Americans!).

(b) Foreign: Australia's national society received space in previous issues. Now comes word that the Society of Instrument Technology has been formed in England and is headed by Sir George P. Thomson. Among its objects are:

Advancement of instrument technology by the dissemination and coördination of information relating to design, application and maintenance of instruments;

Discussion between designers and manufacturers on the one side, and users on the other;

Encouragement of technical education for persons who wish to enter or are already in the industry;

Encouragement of research into problems relating to instrument technology;

Standardization of instruments and accessories by collaboration between manufacturers and users;

Determination of a commonly acceptable terminology;

To enhance the status and prestige of those employed in the industry.

4. ADVERTISEMENTS IN GENERAL MAGAZINES—*(a) Manufacturers:* Aircraft, gun, ammunition and radio manufacturers advertise their use of recorders and controllers. Recent consumer-goods ads feature chart records as proof of quality. Instrument manufacturers' advertising in general magazines is likewise a tribute to the American public's growing instrument-mindedness.

(b) Instruments Publishing Co.: Designed to "sell" Instrumentation to executives, the first in a series of advertisements of *Instruments* appeared in the Aug. 15 issue of *Modern Industry.* This ad (see page 562) will be followed by eleven others on the importance of Instrumentation in plants, in laboratories, in aircraft, etc. This campaign really advertises YOU to the "big shots" of industry. You can (and should) help by sending to *Instruments* the names of executives and plant officials who are concerned with cutting costs, improving quality and eliminating guesswork: Reprints of these ads will be mailed to them.

—MFB

George Washington University

A two-evening-a-week course in the Principles of Instrument Design is being given by the School of Engineering, George Washington University, Washington, D. C. It began on Sept. 4 and will end Dec. 15. Conducted by R. C. Darnell, it is intended to provide the basic engineering knowledge required by engineers, physicists and technicians having occasion to develop or use special instruments in connection with the war effort.

This is an ESMWT course sponsored by the U. S. Office of Education, tuition free to qualified students: two years of an engi-

(Continued on page 558)

No! Paul Isn't Retiring

ONE of the boys at Westinghouse in Newark (NJ) was just given a big send-off by the other boys. He's a lad by the name of Paul MacGahan. The occasion was said to be his retirement but I know it ain't so, 'cause he's just 70 and he's only been 48 short years with Westinghouse and he's as full of ideas as when he invented the two-element two-disk polyphase meter (and many other devices) before and after the turn of the century.

Electrical and instrument-makers' magazines will no doubt print details of Paul's career, as if it were over. It isn't over! Paul has only stopped building *things* for one company but he will continue building MEN through his understanding, his sense of values, his humor and his wisdom.

—MFB

"New Principle" Endorsed by Heat-transfer Authority

COLUMBIA UNIVERSITY
Department of Mechanical Engineering
RESEARCH LABORATORIES
HEAT TRANSFER *Aug. 29, 1944*

To the Editor of *Instruments*:

Your editorial suggestion* in the August 1944 issue is highly to be commended. Recent experiments, on which the writer will report within a short time, show in one specific example that the temperature differences measured by a thermocouple in a closed protection tube were between 40% and 43.5% of the true differences of temperature obtained with a thin bare thermocouple. Temperature indications obtained with lagging instruments are meaningless, particularly in rapidly-changing processes

VICTOR PASCHKIS

*". . . A new general principle:

"The lag of the primary element of a thermometer used for checking the effectiveness of a controller must be smaller than (preferably one-third of) the lag of the controller's primary element. The circulation past the test-thermometer bulb must be as fast as the circulation past the controller primary element. The test-thermometer must be of a design and construction which exhibits neither the 'delayed-start' effect nor the 'delayed-end' effect.

"This principle should be adopted by scientific and technical bodies and widely published, to end a source of confusion . . ."

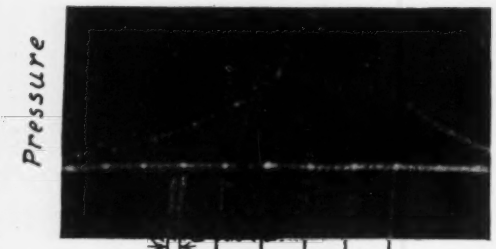

Fig. 1. Pressure Diagram

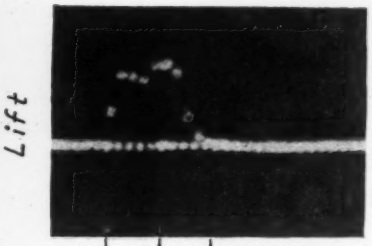

Fig. 2. Needle Lift Diagram

Cathode-ray Oscillograph as an Engine Indicator—Construction of Integrator and Degree Marker

By P. H. SCHWEITZER and FRANZ VEITH, Engineering Experiment Station, The Pennsylvania State College

THE 9-inch RCA Cathode-ray Oscillograph has been so modified as to:

1. Permit the use of electromagnetic pick-ups instead of the standard piezoelectric pick-ups.

2. Produce dotted diagrams instead of continuous line diagrams (see Figs. 1 and 2) the dots serving as a crank angle degree scale.

Electromagnetic pick-ups are preferred because they are less erratic than piezoelectric pick-ups and because they permit recording injection needle lift diagrams which is not possible with piezoelectric pick-ups. One drawback of the electromagnetic pick-ups is that they give a differential or rate-of-change diagram and the record must be integrated to have a normal pressure or lift diagram. Following the method used in the Standard-Sunbury cathode-ray indicator, the integration is performed in the instrument electrically and, by turning two switches, either differential or normal (integrated) diagrams can be produced on the screen.

The electric integrator and degree marker has been combined in one box, shown on the lower shelf in Fig. 3. The amplifier shown above is out of the circuit and inoperative.

Almost any commercial or home-made electromagnetic pick-up can be used with the oscillograph. Fig. 4 shows a Standard-Sunbury needle lift pick-up, Fig. 5 an American Instrument Company cylinder-pressure pick-up and Fig. 6 a Penn State injection-line pressure pick-up.

In the following the construction of the Integrator and Degree Marker is described.

INTEGRATOR

The principle of electric integration is based on an elementary circuit consisting of a resistance R and a capacitance C as shown in Fig. 6. For accurate integration the following conditions are of importance (E. S. L. Beale and R. Stansfield, *The Engineer*, Dec. 13, 20 and 27, 1935):

1. The presence of the integrating circuit must not appreciably distort the form of the voltage to be integrated, i.e. it must offer a relatively high input impedance.

2. The means used for measuring the integrated voltage must not draw any appreciable current from the circuit.

3. The integrated voltage must be negligible compared with the input voltage.

In order to meet the last condition, without reducing the sensitivity of the integrating circuit to an impracticable low, a feed-back circuit is employed which corrects for the voltage on the integrating capacitor and enables an exact integration.

In the circuit diagram, Fig. 7, the integration is performed by means of the resistance $R_6 = 1.0$ megohms and the capacitor $C_3 = 0.15$ microfarad. Two amplifier stages are necessary in order to fulfill the conditions above. It was found that the feed-back voltage should be coupled by means of capacitors, decreasing in capacitance as the

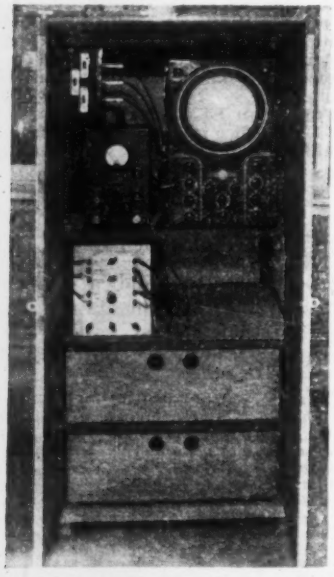

Fig. 3. Cathode-ray Oscillograph. The Integrator and Degree Marker is on the lower shelf. (Note—The amplifier shown on the upper shelf left is out of the circuit.)

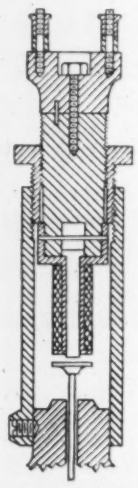

Fig. 4. Standard Sunbury Needle Lift Pick-up.

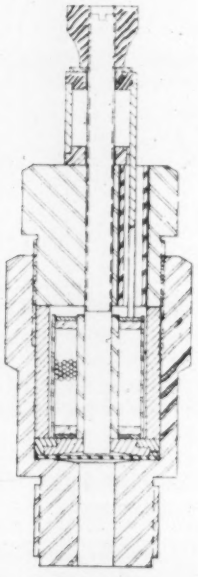

Fig. 5. American Instrument Co. Cylinder - pressure Pick-up.

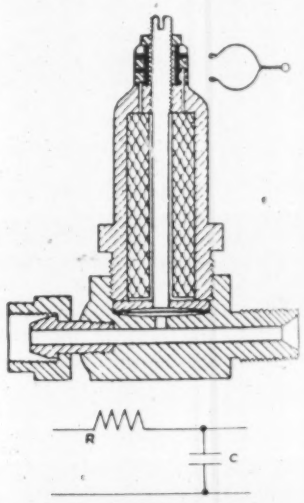

Fig. 6. Penn State Injection Line Pressure Pick-up and Principle of Electric Integration.

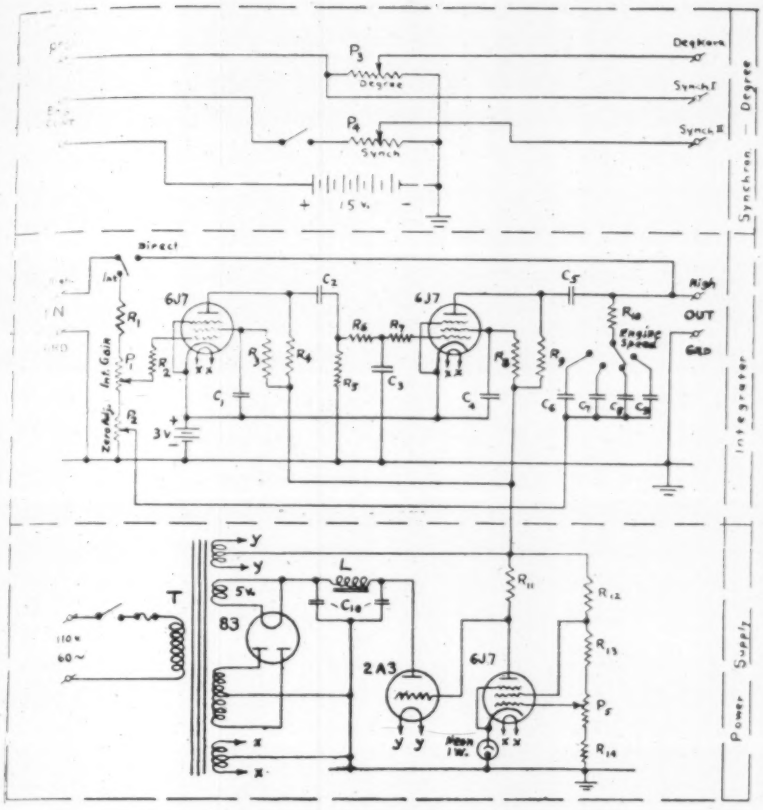

Fig. 7. Circuit Diagram of Integrator and Degree Marker.

P_1 — 0.5 megohm volume control
P_2 — 0-700 ohms volume control for zero adj.
P_3 — 0-1.0 megohm volume control for degree marker
P_4 — 0-1000 ohms volume control for synchronizer
P_5 — 10 megohm volume control

R_1 — 0.5 megohm
R_2R_7 — 1500 ohms
$R_3R_8R_{11}$ — 0.5 megohms
R_4R_9 — 0.1 megohm
$R_5R_6R_{10}$ — 1.0 megohms
R_{12} — 10 megohms
R_{13} — 20 megohms
R_{14} — 5 megohms

C_1C_4 — 8 mfd
C_2C_5 — 2 mfd
C_3 — 0.15 mfd
C_6 — 0.25 mfd
C_7 — 0.1 mfd
C_8 — 0.05 mfd
C_9 — 0.02 mfd
C_{10} — 8 + 8 mfd

L — 15 henry

engine speed increases. A volume control adjusts the feed-back voltage and thus the amount of correction required. It is possible with this control to compensite the error in integration and thus adjust for the correct value.

A simple means of testing the integrating circuit and the effectiveness of the correction adjustment consists in using a square wave, Fig. 8, which can be obtained from a circuit such as shown in Fig. 9.

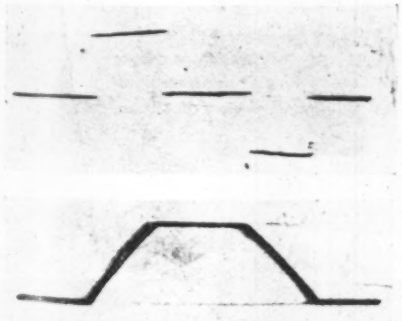

Fig. 8. Integration of a Square Wave. Electric integration of the square wave (upper) gave the trapezoid figure (lower).

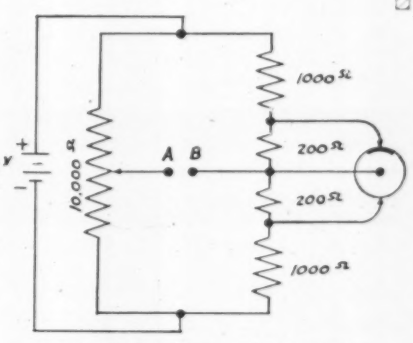

Fig. 9. Circuit Diagram for Integrator.

In integrating this wave, a trapezoid figure as Fig. 8 is expected and the correct integration can easily be recognized by the lack of any distortion. This method of testing is very sensitive and reliable.

DEGREE MARKER

The degree mark emitter developed by Beale and Stansfield for the Sunbury Indicator is used. As shown on Fig. 10 an electromagnetic pick-up is mounted near the periphery of a serrated steel disk which is coupled to the engine shaft. Small notches in the circumference of the disk, spaced every two degrees, produce alternating voltage in the pick-up, as the length of the air gap in front of the pick-up changes with every passing notch. This voltage is connected to the so-called blanking amplifier of the oscillograph, which is coupled to the control grid of the cathode-ray tube. By varying the bias on this grid the intensity of the beam is modulated by the alternating voltage controlled by the engine. The trace on the screen appears then as a dashed line, the horizontal distance between two consecutive dashes corresponding to two degrees shaft rotation. For further orientation the notches every ten degrees can be made somewhat deeper (or longer) and one notch at "top center" still deeper in order to obtain brighter dashes at these positions. For correct adjustment of the "degree marker voltage" a volume control is used.

SYNCHRONIZATION

Synchronization of the indicator diagram on the screen can be obtained by controlling the sweep of the oscillograph. A perfect synchronization is per-

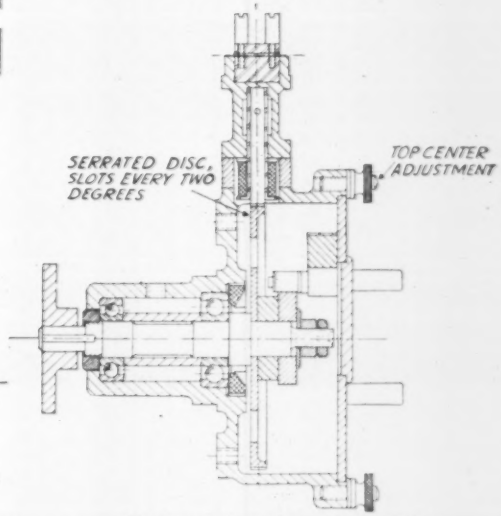

Fig. 10. Sunbury Degree Mark Emitter.

formed if the sweep is controlled by a capacitor which can be discharged by an engine contact. Most standard cathode-ray oscillographs, however, are equipped with a Thyratron-controlled sweep circuit. In this case an impulse on the control grid of the Thyratron tube is able to synchronize the trace sufficiently. The impulse may be obtained by connecting a battery over an engine contact to a volume control. The output of this volume is then connected directly to the grid of the Thyratron tube and to ground.

For synchronization of the degree marker voltage, this voltage is also connected to the usual synchronization terminal of the oscillograph. By means of the synchronization control on the oscillograph the dashes can be stabilized, i.e. prevented from running along the trace.

(Continued on page 560)

SILICONES

new lubricant increases valve life— reduces maintenance costs

Dow Corning Plug Cock Grease is rapidly proving to be an ideal grease for the lubrication of valves and plug cocks. This basically new product—one of a series of recent Dow Corning silicone developments—is highly resistant to attack by alkalies, acids and oxidizing agents. Because it protects the metal plug cock from corrosive liquids and vapors, it reduces corrosion hazards to a minimum, and so affords continuously efficient, *free* valve operation. Too, Dow Corning Plug Cock Grease maintains its vaseline-like consistency throughout an exceptionally broad range of operating temperatures: from −40°F. to 400°F.

Users of Dow Corning Plug Cock Grease in a wide variety of corrosive chemical services report that valve life was increased three to four hundred per cent when they started to use this silicone lubricant.

DOW CORNING SILICONE PRODUCTS INCLUDE:

Fluids—Inert liquids, with viscosity little affected by temperature changes; for operation at sub-zero as well as elevated temperatures.

Resins—High temperature insulating varnishes for use with heat stable electrical insulating materials.

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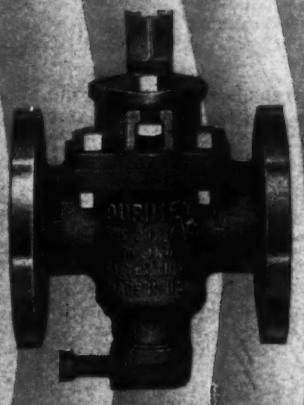
Dow Corning

PLUG COCK GREASE



This Duriron Valve, used in the handling of corrosive materials, is but one of many instances where the use of Dow Corning Plug Cock Grease will afford longer life and more efficient operation.

DOW CORNING

Multiple-diaphragm Pressure Regulators and Their Application

By H. C. McRAE, Research Engineer, The North American Mfg. Co., Cleveland, Ohio

THE most common pressure regulator in use is the single-diaphragm type* but this may not always be the case, as advantages offered by the multiple-diaphragm pilot regulators or relays may offset their additional cost.

Fig. 1 summarizes the simplest form of pressure regulator. The principle is easily seen to be essentially a balance of two forces: the spring force opposing the force of the outlet pressure on the diaphragm. Any disturbance in the upstream or downstream line, which may tend to increase the outlet pressure, immediately pushes upward on the diaphragm, closing the valve, until the correct discharge pressure is restored. There are other smaller forces or variables which tend to cause the outlet pressure to deviate from the correct value. These errors come from a variation in force of the spring for various valve openings, from the change in effective area or coefficient of the diaphragm, and from the variation in force on the valve head under various pressure conditions. The same errors are likely to be present in multiple-diaphragm regulators, although it will be seen how they can be minimized.

Fig. 2 shows an assembly of diaphragms attached to a common shaft. Neglecting the smaller forces mentioned above, it is possible to set up equations representing a force balance of the assembly. A_1, A_2, etc., represent effective areas of diaphragms and P_1, P_2, etc., represent the pressures in the various chambers. Since pressure times area is force and the sum of all the forces must be zero when the assembly is in balance:

$$(P_1-P_2)\,A_1+(P_2-P_3)\,A_2+(P_3-P_4)\,A_3+(P_4-P_5)\,A_4=0$$

Each of the above four terms represents the force on a diaphragm. Sometimes it is more convenient to consider the force from each pressure chamber in a force balance:

$$A_1P_1+(A_2-A_1)\,P_2+(A_3-A_2)\,P_3+(A_4-A_3)\,P_4-A_4P_5=0$$

These equations are identical when multiplied through. To repeat, a force balance may be taken by considering the force on each diaphragm or by taking the force from each pressure chamber.

Fig. 3 is a pressure regulator used to control the flow of oil in proportion to the flow of air to an oil burner. This is accomplished by maintaining a constant ratio of pressures between the two fluids. The chamber between the two diaphragms is vented, so as to keep $P=0$.

$$P_1A_1=P_2A_2 \text{ or } P_1/P_2=A_2/A_1$$

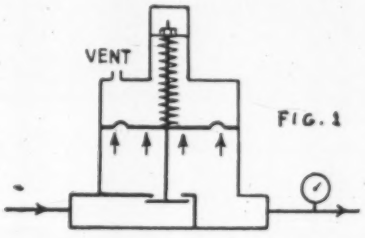


FIG. 1

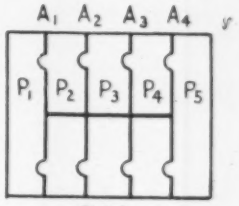


FIG. 2

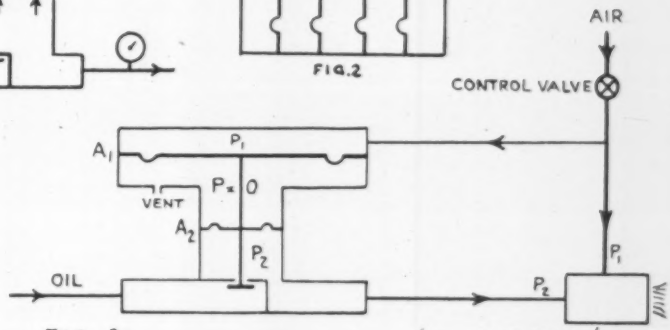


FIG. 3

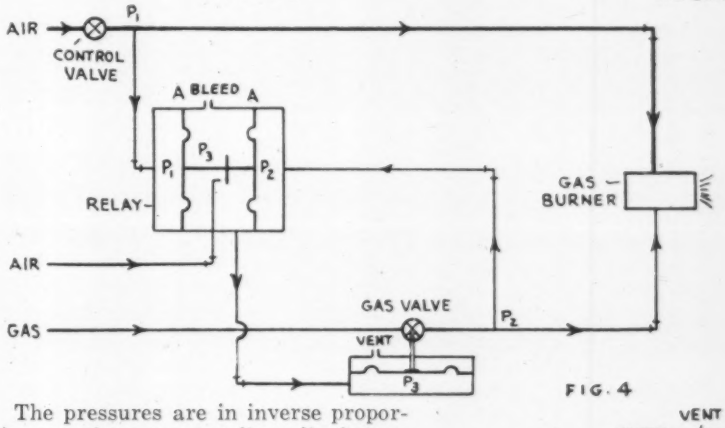


FIG. 4

The pressures are in inverse proportion to the corresponding diaphragm areas. A_2 is made small in comparison to A_1, so as to obtain a necessary higher oil pressure than air pressure.

The simplest type of relay is shown in Fig. 4. This control circuit is used to proportion the flow of large quantities of fuel gas to air as required for combustion. A single-diaphragm unit regulator would be much too large to be practical. It is also used for controlling smaller flows of dirty gas. A control valve in the main air line is operated manually or automatically according to temperature demands. The gas valve is operated by a diaphragm. The relay adjusts the pressure, P_3, on this diaphragm in such a manner as to keep the gas pressure, P_2, equal to the air pressure, P_1.

$$(P_1-P_3)\,A=(P_2-P_3)\,A \text{ or } P_1=P_2$$

In the relay, if P_1 should momentarily exceed P_2, the diaphragms move to the right, opening the small valve in the middle pressure chamber and increasing P_3 which in turn opens the gas valve until P_2 is made equal to P_1.

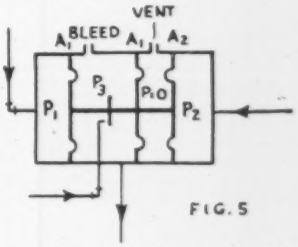


FIG. 5

There is a constant flow of air through the small valve and out the bleed hole in the middle chamber as shown.

The valve in the relay is placed between diaphragms of equal area, producing a dead pressure region as far as the balance of the relay is concerned. This principle is used in the relays to follow. The valve area is very small compared to the size of the diaphragms, hence the error from this source is negligible. In fact, the relay, when properly constructed is a precision instrument, producing accuracies in the field of combustion not possible with the ordinary pressure regulators.

If the gas pressure available is not high enough to match the air pressure, or vice versa, a ratio of pressure is maintained by a relay as shown in Fig. 5, which is used in the same manner as the relay in Fig. 4. A force balance on the three-diaphragm relay is:

*The principles of the single-diaphragm pressure regulator have been discussed in an article entitled "Simple Pressure Regulators—Principal Types and Their Characteristics," by the author in the February 1942 issue of *Instruments*, pages 44-45, 59. It is recommended that the reader review this article before reading the present one.

$$P_1A_1 + P_3(A_1 - A_1) - P_2A_2 = 0$$
$$P_1A_1 = P_2A_2 \text{ or } P_1/P_2 = A_2/A_1$$

So far, the problem has been to balance two pressures in a constant ratio. Very often differential pressures across orifice plates are held in constant ratio to maintain a constant flow ratio of fuel and air. Fig. 6 is an illustration of a pressure regulator used to balance differential pressures. (No valve is shown.) The equation of force is:

$$(P_1 - P_2)A_1 = (P_3 - P_4)A_2 \text{ or}$$
$$(P_1 - P_2)/(P_3 - P_4) = A_2/A_1$$

The undesirable feature about this device is the use of bearings at the points x. The leak of gases through these bearings must be kept at a minimum and the friction on the diaphragm shaft must be negligible. If small diaphragms are used in place of the bearings, errors in the force balance are set up due to pressures acting on the small diaphragms.

One means of overcoming the above difficulty is to mount the small diaphragms at right angles to the large diaphragms as in Fig. 7. The arms N pivot about axles at points x mounted as part of the small diaphragms. Thus, the effect of the pressures P_2 and P_4 on the small diaphragms is null with respect to the general force balance. (As in Fig. 6, the valve has been omitted.) However, the device in Fig. 7 is costly to build because of the many bearings used.

At this point, it is now possible for the reader to understand the advantage of the multiple-diaphragm relay which overcomes the above difficulties, has no bearings and is simple in construction. Fig. 8 illustrates the principle of the differential pressure relay, although the actual construction is more simple than this, as will be shown later. The relay in Fig. 8 has a balance of forces:

$$(P_1 - P_2)A_1 + P_2(A_3 - A_4) - P_2(A_3 - A_4) = (P_3 - P_4)A_2 + P_4(A_5 - A_6) - P_4(A_5 - A_6)$$

or $(P_1 - P_2)/(P_3 - P_4) = A_2/A_1$

In other words, the effect of the downstream pressure on the second diaphragm is nullified by introducing this pressure into another chamber, which has *diaphragms of the proper area with respect to the second diaphragm*. Thus, when the differential pressure ratios are thrown out of balance, the small valve in the relay changes the pressure P_5 on the gas valve actuating diaphragm until the differential pressures are again in balance.

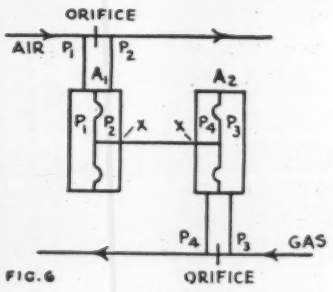


FIG. 6

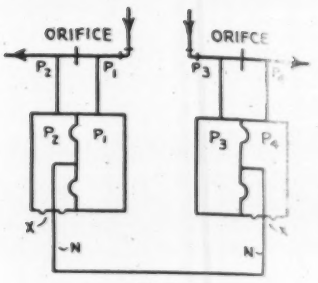


FIG. 7

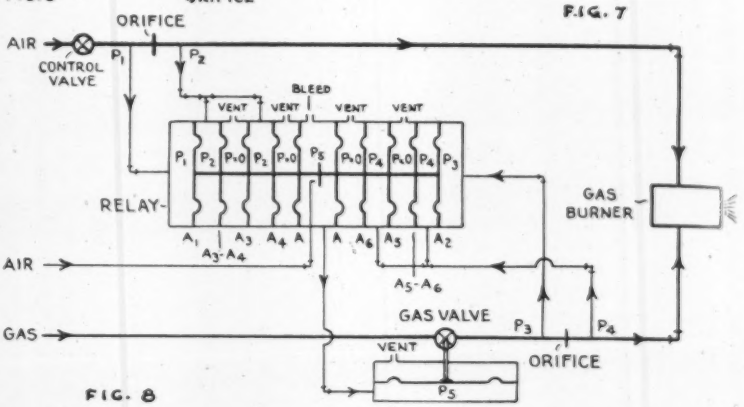


FIG. 8

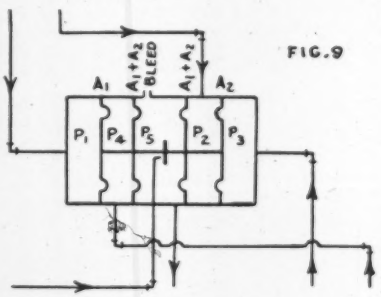


FIG. 9

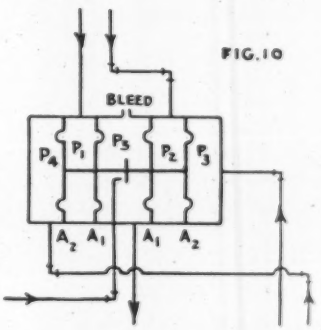


FIG. 10

In Fig. 9 a much simplified relay is shown with only four diaphragms instead of ten as in Fig. 8, although it is used for the same purpose. The force balance is:

$$P_1A_1 + P_4[(A_1 + A_2) - A_1] = P_3A_2 + P_1A_1 - P_2A_1 = P_3A_2 - P_4A_2P_2[(A_1 + A_2) - A_2]$$

$$(P_1 - P_2)A_1 = (P_3 - P_4)A_2$$
$$\text{or } (P_1 - P_2)/(P_3 - P_4) = A_2/A_1$$

As in the previous case, the downstream pressures from the orifices are made to oppose the upstream pressures by proper sizing of surrounding diaphragms. It is also possible to construct a relay with the upstream orifice pressures being surrounded by diaphragms and the downstream pressures applied on the end diaphragms. In fact, there are many combinations of diaphragms which will operate together as a relay, of which probably the most simple combination is illustrated in Fig. 10.

In this case:

$$P_4A_2 + P_1(A_1 - A_2) = P_3A_2 + P_2(A_1 - A_2)$$
$$(P_1 - P_2)(A_1 - A_2) = (P_3 - P_4)A_2$$
$$(P_1 - P_2)/(P_3 - P_4) = A_2/(A_1 - A_2)$$

The advantage of this construction over that of Fig. 9 is the fact that a ratio of differential pressures may be obtained without the necessity of building a diaphragm with an effective area

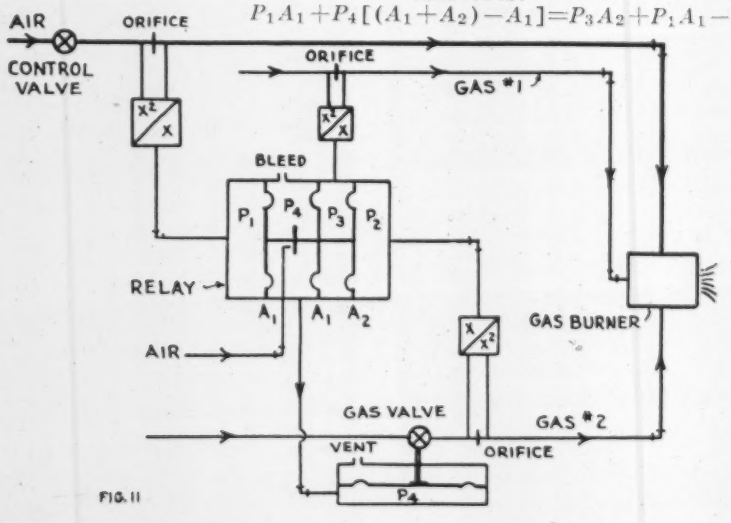


FIG. 11

exactly equal to the sum of two other areas. It also has the advantage of producing a high ratio of differential pressures (when needed) without constructing diaphragms of large differences in size in the same unit; in fact, as A_1 approaches A_2, this ratio becomes infinity.

It should be noticed that in relays controlling differential pressures, there is no need for vented pressure chambers; that is to say, THERE IS ALWAYS AT LEAST ONE COMBINATION OF DIAPHRAGMS SUCH THAT, WITH "n" PRESSURES INVOLVED, THERE ARE "n" PRESSURE CHAMBERS AND $(n-1)$ DIAPHRAGMS.

Perhaps one more relay design or application is worth mentioning, although it is not a very common application. In the simultaneous combustion of two gaseous fuels, one of which is always of insufficient quantity and cheap while the other gas is plentiful and more costly, the total air supplied must be in proportion to the sum of the two gases. This is accomplished by controlling the air supply according to the temperature demand and augmenting the variable supply of the cheaper fuel with a relay controlled flow of the other gas as in Fig. 11. Since flow is proportional to the square root of the differential pressure, and the two gaseous flows must be added, use is made of the symbol $|^{x^2}/_{x}|$*, which is a square root modulator. This device produces a single pressure which is proportional to the square root of the applied differential pressures and is then applied to the relay. The equation of forces is:

$$P_1A_1 = P_2A_2 + P_3(A_1 - A_2)$$

If either the air flow should increase or the #1 gas flow decrease, the relay increases P_4 and the #2 gas flow until the sum of the two gas flows corresponds to the air flow.

It is believed that the relay application will replace not only the simple pressure regulator but also, in some cases, the use of compressed-air and hydraulic devices on the more complicated applications as illustrated in Figs. 8 to 11. The simple, inexpensive construction of the relay and its use of low-pressure air will continue to find an application in the field of automatic control.

*C. J. Geiser, Modulator Control for Multifuel Fired Furnaces. *Iron & Steel Engineer*, August 1943, pages 35-39.

Testing Procedures in Relation to Production*

By HUGH E. FERGUSON, Plant Testing Engineer, People's Gas Light & Coke Co., Chicago, Ill.

TESTING activities in large industrial organizations may be divided into three general fields:

(1) The testing and evaluation of *materials*, both raw and produced;

(2) The observance and recording of *operations*, for control purposes;

(3) The maintenance and adjustment of *equipment* and instruments.

It would be impossible to discuss even only one of these three fields of testing in any great detail in only 15 or 20 minutes—but by commenting upon one subject in each of the three fields it may be possible to illustrate the value of testing work in relation to production.

TESTING OF MATERIALS

First let's consider the testing and evaluation of materials — particularly as applied to the purchase of raw materials. When purchases are made in accordance with the specifications system, the *purchasing company* tries to dictate and control the properties and qualities of the material involved. On the basis of his past experience, the purchaser decides what properties he wants in the raw materials that are going to be bought, writes these desires out in the form of specifications, and then tries to get a producer to provide such materials at a reasonable price. In buying by specifications, the purchaser should make continuous tests of the material as it is received to make certain that it meets requirements—otherwise he will not be able to detect and reject materials that do not meet his desires, and might just as well do his buying without formal specifications.

As the specifications for particular materials become well-known and widely used, producers tend to grade their products to conform to them—and this results in a constant tendency to change from "specification buying" to "standard-grade" buying, a tendency fostered by the activities of such organizations as the American Standards Association, Underwriters Laboratories, and certain technical societies. This change from specifications to standard grades has the result of shifting the burden of proof of quality from the purchaser back to the seller; this might be desirable, if it were not for the fact that invariably the seller will attach a higher price to any material that he has graded or tailored to meet somebody else's requirements or specifications. However, if the purchasing company has a staff and technical facilities capable of drawing up and enforcing satisfactory materials specifications, it should be able to use this staff to go bargain-hunting for batches of material that are not graded according to standards or do not fulfill formal specifications.

In this "bargain-hunting" system of purchase, the buyer first obtains from the seller a representative sample of the raw material under consideration—together with a statement of the seller's asking price. This sample is tested by the purchaser, and the results of the tests made on it are compared with the averages of the results of tests made on a number of representative samples of similar material in recent months. If material of *average* quality is assumed to be 100, the "quality-rating" figure of the sample will be a percentage expression, indicating its value as compared to material of contemporary average quality. From the "quality-rating" of the sample, and the contemporary open-market price for average-quality material, the purchaser can determine the most economical price to pay for the lot of raw material represented by the sample.

As an illustrative example: let's suppose that an oil refiner has some peculiar oil stock which he considers to be useless for anything except use as a fuel—and which he is willing to sell at the prevailing market price for fuel oil of 3 cents per gallon. Testing of a sample of this oil indicates it to have a gas-making or carbureting quality rated at 125% in comparison with 35 or 40 other gas oils recently tested by the purchaser. If the open-market price for average-grade gas-making oil at that time is 4 cents per gallon, the purchaser can afford to pay 5 cents for this material which the refiner is willing to sell as fuel oil for 3 cents per gallon.—(Caveat vendor, instead of caveat emptor!)

On the other hand, if tests of the sample indicated it to have a "quality-rating" of 70% as a gas-making material, giving it a contemporary value of 2.8 cents per gallon, the purchaser could logically refuse to pay 3 cents per gallon for it. I know of one company which credits itself with savings of several million dollars in the purchase of a single raw material in the period of five years, through judicious use of this bargain-hunting system to avoid buying substandard materials and to insure minimum prices. Note that the aim of this bargain-hunting system of purchasing is to test the asking price as well as to determine quality of the material—by bringing the contemporary open-market price of average-quality material into consideration.

TESTING OF OPERATIONS

One outstanding feature of the testing of operations is the wide degree of variation which exists in its application; in some instances testing is only countenanced as a necessary evil—but in other instances tests results completely control operations.

Some companies utilize testing only for post-mortem work or trouble-shooting—applying their technical facilities merely to find out and correct some-

(Continued on page 562)

*Presented at the WPB-CTSC War Production Conference, Chicago, March 30, 1944.

ELECTRON TUBES—Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER, Managing Editor, *Power Plant Engineering*, Chicago, Ill.

XXIII. TUBES AND THEIR CLASSIFICATION

(Concluded)

The reader who has followed this series of articles thus far is familiar with the meaning of many of the groupings in the accompanying tabulation but there are others which will sound quite strange. The terms Class B triodes and Class C Power Amplifier triodes, for example, have not been touched on in these articles, nor have a number of the others. This need not cause discouragement, however; many of these terms have application only in communication work, in circuits involving voice or voice-modulated high frequencies. We need not discuss these things in detail here, but a few words of explanation may remove some of the element of mystery.

Class A, B, and C are terms used to express the different methods used in operating amplifiers. This is largely a function of the way the tube is operated with respect to grid bias although certain tubes are better adapted to certain kinds of operation than others. A Class A amplifier is one in which the shape of the output wave is a faithful reproduction of the input wave. A Class B amplifier when operated correctly will also provide an accurate reproduction of the input voltage at the output but it has a higher plate efficiency* than the Class A. A Class C amplifier has relatively high distortion but also very high plate efficiency. These methods of operation will be explained in greater detail in a subsequent article.

Such terms as duodiode, duodiode-triode, etc., as appear in the tabulation obviously refer to combinations of diodes or triodes in a single glass envelope. The tubes considered thus far have been diodes, triodes, tetrodes, and pentodes. It is quite possible to combine two or more of these types in one tube. Thus, a duodiode or duplex diode is a tube with two diodes combined in one tube, represented by the full wave rectifier. A twin triode is one with two triodes in a single tube. Such a tube is shown in Fig. 157. It can be used as a detector and a one-stage amplifier, as a two-stage amplifier as an oscillator and amplifier, as a push-pull amplifier as well as in other ways.

*By plate efficiency is meant the ratio of a-c. output power to steady d-c. input power. The plate efficiency of the Class A amplifier is relatively low—from 20 to 35 percent at full output depending upon the design of the tube and the operating conditions.

Classification of Electron Tubes according to Function

1. Low-power high-vacuum rectifiers
   A. Half-wave
   B. Full-wave
2. High-power high-vacuum rectifiers
   All half-wave
3. Gas rectifiers
   A. Half-wave
   B. Full-wave
4. General-purpose triodes (low power)
   May be used as detector, oscillator, voltage and low-power amplifiers
5. General-purpose triodes (intermediate power)
6. Class B triodes
   Special Class B power amplifiers—triodes and duotriodes operated with no bias on control grid
7. Class B and Class C Power-Amplifier Triodes (intermediate power)
   Used particularly for Class B and C amplifiers and oscillators
8. Water-cooled Triodes
9. Internally screened voltage-amplifier tetrodes and pentodes
10. Unscreened Power-amplifier tetrodes and pentodes
11. Internally screened power-amplifier tetrodes and pentodes
12. Duodiode-triodes and duodiodes
13. Duodiode-pentodes and triode pentodes
14. Special five-grid oscillator-modulators and frequency converters
15. Special ultra-high-frequency oscillators
    A. Split-anode magnetrons
    B. Electrnic oscillators
16. Electrometers
17. Current regulators
18. Voltage regulators and surge protectors
19. Ionization gages

Fig. 157. Diagram of a twin triode using indirectly-heated cathodes.

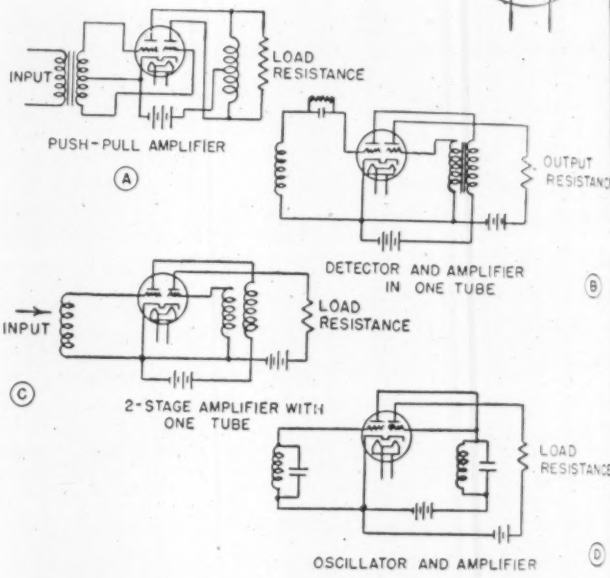


Fig. 158. Various applications of the twin triode

A, shows a push-pull amplifier using a single tube. In the push-pull amplifier two tubes are ordinarily used with their grids and plates connected to opposite sides of a balanced unit. The cathode returns are made to the midpoint of the input and output transformers or resistors. In this case, the circuit is exactly the same except that the two tube elements are incorporated in a single envelope.

B, C, and D, are self-evident; in each instance the elements of what would ordinarily require two tubes are incorporated in one tube. These diagrams are presented only to indicate principles, not actual circuits.

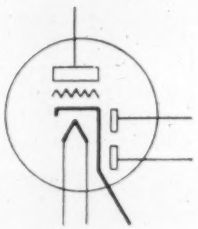


Fig. 159. A duplex diode triode.

Such tubes are called multi-purpose tubes and while they can be used to some extent in industrial applications they were devised primarily to do special work in radio receiving circuits. The simplest are the duplex diodes and twin triodes already mentioned. To add the functions of diode detection and automatic volume control in radio receivers to that of amplification a number of types are made in which two diode plates are placed near the cathode but not in the amplifier-portion structure. The diagram for such a tube is shown in Fig. 159 which is a duplex diode triode. A typical tube of this type is the 55 used as a full-wave diode detector

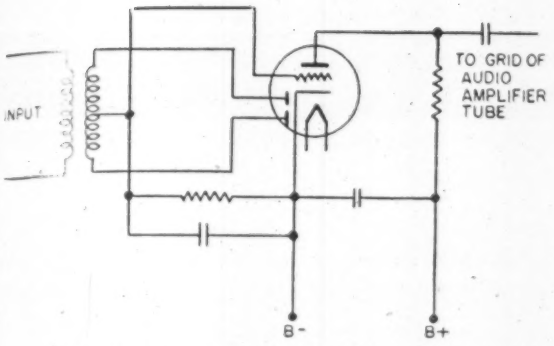


Fig. 160. Duplex diode triode used as a full wave diode detector and amplifier in a radio receiver circuit.

and amplifier in Fig. 160. The two diodes are used as a full-wave detector (rectifier) feeding the triode as an audio-frequency amplifier. These matters are of interest largely to radio engineers but they are presented here to show how flexible the electron tube is in its application.

Another tube of great usefulness in radio receiver work is the so-called pentagrid converter, a tube which, as its name indicates, has five grids and which combines the functions of a detector and oscillator in superheterodyne receivers. It is shown diagrammatically in Fig. 161. In the

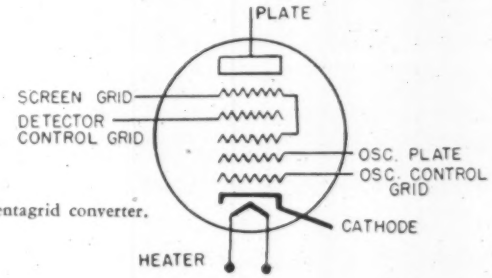


Fig. 161. The pentagrid converter.

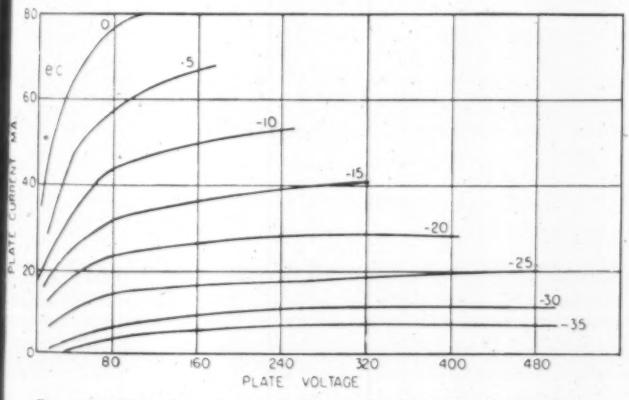


Fig. 162. The plate characteristics of the 2A5 operating with a screen voltage of 250.

superheterodyne receiver, the incoming signal frequency is converted to a lower (intermediate) frequency by combining it with a locally-generated high frequency and then amplifying this resulting intermediate frequency by ordinary amplifiers. The local frequency in the early receivers was always generated by a separate local oscillator, the output of which was combined in the first detector tube with the incoming signal frequency. With the pentagrid tube both of these functions, i.e., the generator of the local frequency and detection, are combined in a single tube. The two inner grids serve as control grid and plate of a small triode oscillator, while the fourth grid is the detector control grid. The third and fifth grids are connected together to form a screen grid which shields the detector control grid from all other tube elements. The pentagrid converter obviates the need for special magnetic or electrostatic coupling devices in the circuit since the mixing of the two frequencies is done electronically in the tube.

While considering the classification of tubes it is desirable here to mention briefly the beam power tube.* The beam power tube is a special type of tube designed to extend the range of operation beyond that possible with the tetrode and at the same time eliminate what may be regarded as the over-effectiveness of the suppressor grid of the pentode. If the characteristics of certain types of pentodes are studied, those designed for large power outputs, it will be found that there is gradual bending of the plate characteristics at low plate voltages. This is evident from Fig. 162 which shows the plate characterictics of a 2A5 operating with a screen voltage of 250. Below 100-volt plate potential it will be seen that the plate current varies greatly with small changes in plate potential. This rapid change in plate current with plate voltage is the result of non-uniformity of the field in the plane of the suppressor. Saturation is obtained at different plate voltages for different sections of this plane and this causes distortion. Some of the primary electrons may be deflected by the field of the suppressor grid and their velocity in the direction of the plate reduced. The field of the suppressor

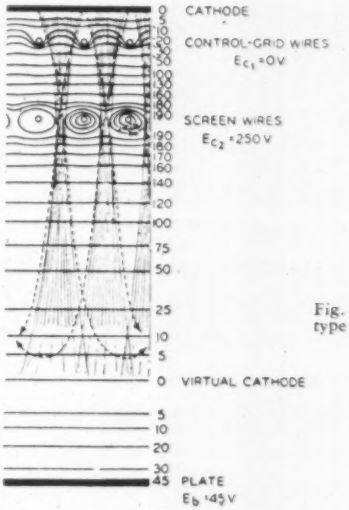


Fig. 163. The potential field of a type 6L6 beam power tube.

grid may actually repel some of the primary electrons back to the screen.

These undesirable characteristics of the power pentode are almost entirely overcome in the beam power pentode. In the beam tube the secondary electrons are returned to the plate by the repulsion of a negative space charge between the screen and the plate. By properly proportioning and arranging the control and screen grid wires and by means special beam forming plates, the electrons emitted by the cathode are directed into a group of beams, as depicted in Fig. 163. These beams, it will be seen, diverge after they pass between the screen grid wires and result in a highly uniform electron distribution in a region between the screen and the plate. The space charge of this concentration of electrons in this region is so dense that it results in the formation of a *virtual cathode*, (i.e., a plane of zero average field and zero electron velocity), near the plate at low plate voltages. This virtual cathode has an effect similar to the suppressor grid but if the density of the space charge and the electron velocity in the region of the virtual cathode are uniform and the distance of the virtual cathode from the plate is the same everywhere, saturation takes place simultaneously at all points in the plane of the virtual cathode and the knee of the plate characteristic is sharp. The virtual cathode and the plate act in a manner similar to the diode, the plate current being limited by space charge at low voltages. There is one important difference, however. In the case of a diode the electrons leave the cathode with almost zero initial velocity, in the beam type of tube the electrons that pass

(Continued on page 554)

*Beam Power Tubes. O. H. Schade. *Proceedings I.R.E.* Vol. 26, Feb. 1938, page 137.

ELECTRIC GAGING METHODS
for Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, University of Illinois

V. GAGING METHODS BASED ON VARIATIONS OF RESISTANCE.

§ 1. Fundamental Methods.

Elements in which an ohmic resistance is changed constitute the third of the three major classes of electric gaging elements.

The change in resistance of an electric element may be accomplished by one of these methods.

(1) Movement of contacts (changing either area or length of the resistance element);

(2) Change in resistance of an element by changing its temperature; or

(3) Change in resistance of an element by changing its dimensions.

In the second and third of these the change in resistance of the element comes principally from the change in resistivity of the material of which it is composed; that is, the material has either a temperature coefficient of resistivity or a stress coefficient of resistivity.

There are also other methods, less widely used, and not exactly fitting into any of these three categories; they may be considered as comprising

(4) Miscellaneous.

A fundamental difference between variable-resistance gaging elements and the others which have been described lies in the fact that while the capacitive and inductive types permit the movement to affect only the length of a small air-gap, in the resistive types the actuating phenomenon in general is allowed to affect the entire mass of resistance material. Consequently it is not possible to provide an increase in sensitivity simply by making an air-gap smaller. Another difference is that the construction of resistive elements is often such as to make necessary the application of a considerable force in order to move a sliding contract along a resistive element or to change its dimension. This, however, is not always true, nor is it always a disadvantage.

A complete analysis of resistive elements involves the fundamental factors affecting the electrical resistance of conductors. Resistance is increased, for example, if the length of the conductor is increased, or if its cross-sectional area is decreased; these are changes in *dimension* of the material. Changing a *property* of the material can also produce the same effect, as when a change in temperature causes a change in the resistivity of the material. (Resistivity may be defined as the resistance between opposite faces of a centimeter cube of the material; it provides a basis for comparison of properties only, since the dimensions of the specimen are fixed.) Changes in dimension and in properties may occur simultaneously. For example, heat applied to a copper wire will cause an increase in its dimensions and in its resistivity; likewise if a wire is subjected to hydrostatic pressure (or to strain) both its dimensions and its resistivity are changed.

Some of the resistance effects employed in gaging devices are obscured or partially concealed by constructional features; for example, in a carbon microphone an increase in pressure increases the area of contact between adjacent carbon granules and thereby decreases the resistance of the mass. Somewhat the same effect occurs in carbon-pile instruments. Both forms are therefore classed as moving-contact instruments; yet an elastic deformation of the carbon does occur, and could justify their inclusion in another category.

In variable-resistance elements in which a liquid (an electrolyte) is the resistance material, movement of the electrodes changes the length and perhaps the distribution of the current paths while not affecting the resistivity; in these same elements change in temperature may change the resistivity while not affecting either the length or the distribution of the current paths. Such a device therefore might be placed either in the moving-contact or in the temperature-responsive group.

The intrinsic sensitivity (resistance change compared to actuating movement) of resistance-type gages varies greatly. The effective resistance of a moving-contact element can vary from nearly zero to nearly the maximum value of the element. Thermosensitive elements can suffer changes in resistance equal to as much as half their maximum values, but in normal operation 20% is a more common range of variation. Strain-sensitive resistance elements, however, do not in general experience resistance changes greater than perhaps 5% of their maximum values; most such elements in actual use do not change by as much as 2%. These ranges must be taken into account in the design of the associated equipment, and also in the selection of a method for a particular application.

§ 2. Moving-contact Elements.

The most widely-used variable-resistance devices are those in which the position of a movable contact determines the effective resistance of the element. Such a device may be a single continuous wire carrying a moving contact (as in the slide-wire or meter bridge); it may be an assembly of coiled or folded wire with movable contacts; it may be a tapped resistance coil with a contacting arm bearing upon the taps. The resistance material may be non-metallic; carbon or carbonaceous materials are often used. It may be liquid—mercury or an electrolyte. Although most of the variable-resistance elements in actual use are not intended as devices to measure the motion which actuates them, any resistor whose resistance can be altered by an adjustment can be utilized to measure the adjusting motion.

Moving-contact resistance elements are made in many different mechanical forms, to suit different applications. In some the movement changes the effective length of the resistance element (as in the slide-wire rheostat); in some the area of the element is changed, either actually or effectively by changing the number of conducting paths in parallel. Occasionally the action is obscure: it may be a combination of several simultaneous effects.

A simple slide-wire rheostat can be employed to measure the movement of any object to which the moving contactor can be attached. For linear movements the resistance element should be straight, while for angular displacements it should be disposed around a circular form. If its cross-section is constant throughout its length, the change in resistance will be proportional to the movement of the contact, whether the motion is linear or angular. When it is

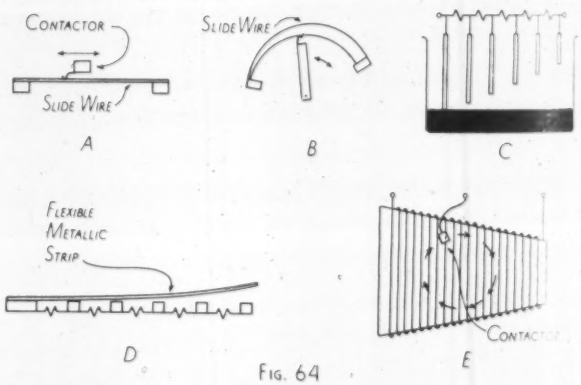


FIG. 64

desired that the resistance change should not be directly proportional to the change of position, the cross-section of the resistance element can be varied along its length.

Electrically, a moving-contact element can be employed either as a *rheostat* or as a *voltage divider*. ("Everybody"

knows th[illegible] but an emphatic reminder may not be out of order.)

Some [illegible] the forms taken by resistance elements are shown in Fig. 64. In this figure, form A is one which is suited for measuring linear or translatory displacements; it is in effect a slide-wire rheostat. An element of similar form, but designed for measuring angular displacements, is shown as Fig. 64B; this device (as indicated by the varying width of the resistance element) experiences a resistance change not directly proportional to the angular movement. A somewhat similar pick-up, designed for a special application, was shown in Fig. 60. Diagram C in Fig. 64 illustrates a form designed for the indication of liquid levels; it includes a tapped resistance coil with the taps brought out to conducting metallic rods of varying lengths.[143] These rods dip into a container of mercury whose level is changed in accordance with the liquid level being measured and, as each rod in turn contacts the mercury, another section of the resistance element is shunted out. In another form, the vertical rods are made of a high-resistance material, and are connected together at their upper ends; thus as the level of the mercury is changed more parallel conducting paths are made available. Water levels are sometimes measured with the water itself replacing the mercury in the measuring element; this is possible if the resistances of the gage elements are high compared to that of the water. (A more common form of the liquid-level indicator is the automobile gasoline gage; its primary element is usually like that of Fig. 64 B.) Diagram D indicates a form occasionally used in pressure gages, in which contacts spaced along a resistance element are successively shunted out by a flexible metallic strip which is forced against them by the movement of a Bourdon tube or other pressure-responsive mechanical element. The last of the forms shown, at E, is an unusually interesting one; it is a part of an apparatus for taking indicator cards.[144] Its wire resistance element is wound upon a tapered card form, so that when a contact is moved in a circular pattern over one surface of the element the resistance variation is proportional to the piston travel of the engine. This movement is *not* simple harmonic motion.

The forms diagrammed in Fig. 64 are representative only; it is impracticable to illustrate all that have been used. Some, for example, employ a bimetallic thermal element to operate a moving contact;[145] others employ Bourdon tubes or diaphragms in a similar manner.[146] Pressure differences are measured by installing two opposing expansive bellows to actuate a single slide-wire element.[147] An interesting form designed for converting angular displacements (as in telemetering the indications of a pressure gage or the like) employs a closed circular tube half-filled with mercury, and with a platinum wire stretched around

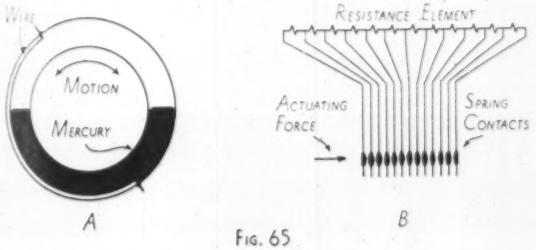


Fig. 65

a portion of the periphery of the tube. As this assembly is rotated, a greater or smaller proportion of the wire is shorted out by the mercury; the entire assembly is thus essentially a frictionless slide-wire rheostat. It is shown as Fig. 65A. Another form, which can control large currents, is used in generator voltage regulators and similar applications; it is a tapped resistance unit with the taps brought out to a series of contacts attached to closely-spaced spring leaves (see Fig. 65B). A small force acting over a short distance can control this element.[148] These are mechanical modifications of some of the forms of Fig. 64.

The carbon microphone is a form of variable-resistance element; in it the variation of applied pressure causes changes in the resistance of a confined mass of carbon granules. The exact mechanism of the phenomenon is not known; it appears to be due primarily to the variation in area of the contacting surfaces between adjacent granules. A diagram of a carbon-granule assembly (not to scale) is shown in Fig. 66A. The device is seldom used now as a quantitative instrument, but is still popular as a qualitative

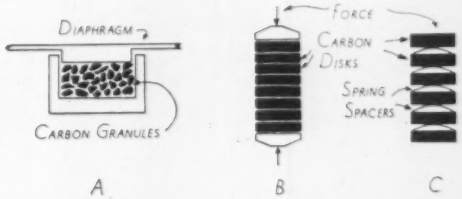


Fig. 66

device. For quantitative measurements, the irregular carbon* granules have been replaced by smooth thin disks of the material, arranged in stacks, as indicated in Fig. 66B. Such a stack or pile of carbon disks suffers a change in its resistance with applied pressure. This change, for a single stack, is not accurately proportional to the change in applied pressure; to improve the linearity the stacks are used in pairs, arranged both mechanically and electrically in push-pull. Fig. 67 is a photograph of a carbon-pile element for measuring fluid pressures; the manner of assembly of the carbon stacks and the coupling of the pressure-responsive diaphragm to these stacks can be clearly seen. Carbon-pile elements have been used to measure forces, strains and accelerations; but now they have been largely superseded by more stable types. The carbon-pile instrument is susceptible to vibration, to temperature changes, and to other extraneous phenomena. Its principal advantage is that it is a low-resistance device capable of providing sufficient output current to actuate most electrical indicating instruments without amplification.

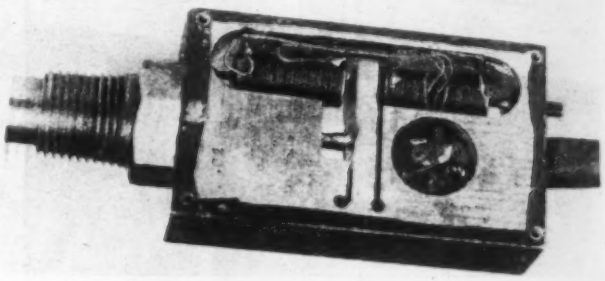


Fig. 67. Carbon-pile Pressure-gage Head.

Although the carbon-pile element is not much used at present as a measuring instrument, it is still widely applied as a current-controlling device. A popular variable-resistance element for heavy currents, used as a laboratory rheostat and as a generator voltage control unit,[149] employs a series of flat plates of hard carbon with deformable

(Continued on page 544)

(143) H. Olken. Electrical Telemetering. *Instruments*, Vol. 5, March 1932, pages 66-74.

(144) J. G. Hempson. Electrical Indicator Drives. *Aircraft Engineering* (London), Vol. 15, 1943, pages 98-99.

(145) G. E. Irvin. Aircraft Instruments. Chapter 3. McGraw-Hill, 1941. 500 pages.

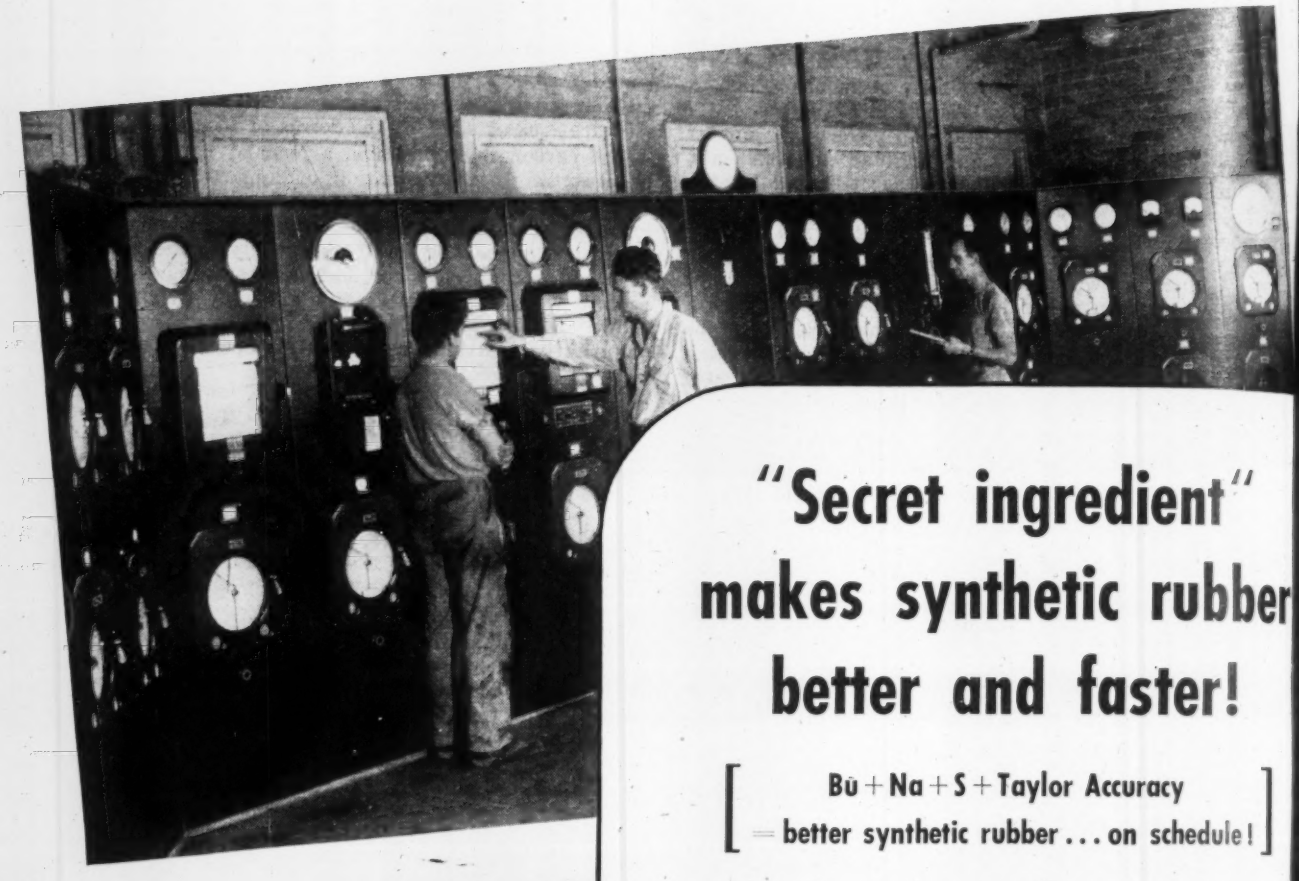
(146) (General Electric Company) New Aircraft Indicating Instruments. *Instruments*, Vol. 4, 1931, pages 129-130.

(147) W. H. Gille and H. T. Sparrow. Electronic Turbo-regulator for Multi-engine Airplanes. *Electronics*, Vol. 17, May 1944, pages 108-112.

*The word "carbon" is used in its generic sense; the material actually used may be carbon, graphite, or a molded carbonaceous material.

(148) C. R. Hanna, K. A. Oplinger, and C. E. Valentine. Recent Developments in Generator Voltage Regulation. *Transactions American Institute of Electrical Engineers*, Vol. 58, 1939, pages 838-844.

(149) W. K. Boice, S. B. Crary, Gabriel Kron, and L. W. Thompson. The Direct-acting Generator Voltage Regulator. *Transactions American Institute of Electrical Engineers*, Vol. 59, 1940, pages 149-157.



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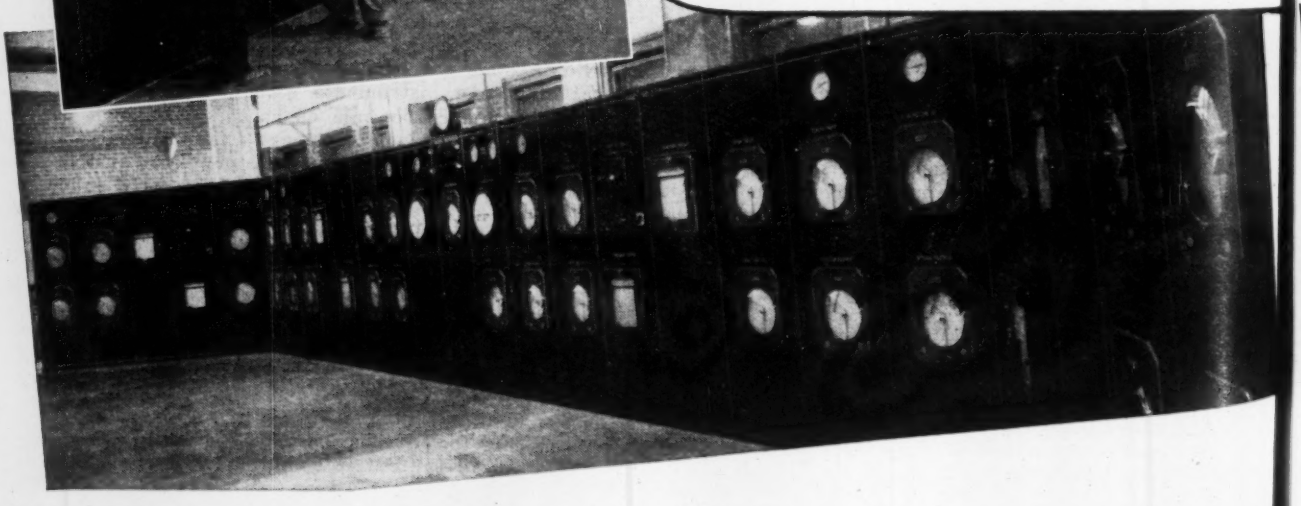

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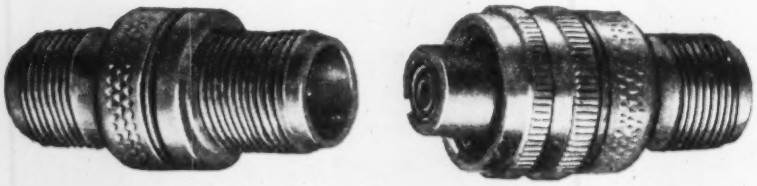

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Vol. III, No. 9 M. F. Behar, Editor September 1944

Suggested Change in Design of the Pendulous Body of Horizon Indicators

By GEO. R. FORD (with Armed Forces overseas)

THE bearings of the pendulous vanes consist of a hole, much too large for the shaft, through which passes the vane tieshafts. The loose fit is necessary in this instance as a very small part of the surface of the shaft contacts the bearing, reducing resistance caused by friction. Furthermore, dirt in the air passing through the bearing under pressure, which is the case, would soon clog the bearing should it fit properly. The constantly-moving bearings, metal-to-metal without lubrication and exposed to the airstream, containing grit, wear rapidly. Soon the lower part of the holes wear to conform with the size of the shaft. The shafts wear at the bottom. The excessive amount of wear permits the vanes to contact the body. The instrument will operate but the accuracy is gone.

The bearings can be repaired, provided the equipment and material is at hand. However, the time required, added to the expense of removing and installing the instrument, would cover the cost of several properly designed and dependable bodies.

The drawings herewith, Figs. 1 and 2, show a pendulous body subject to little or no wear during the life of the instrument. The cost should be little more than that of present models.

Had we had this type, the overhaul expense of horizons would have been reduced at least fifty percent in the shop where I have been working.

SUGGESTED PENDULOUS BODY, HORIZON (SPERRY)
(Could be used also on the Jack and Heintz)

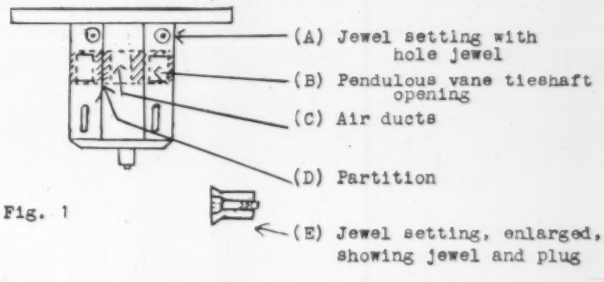
(A) Jewel setting with hole jewel
(B) Pendulous vane tieshaft opening
(C) Air ducts
(D) Partition
(E) Jewel setting, enlarged, showing jewel and plug

Fig. 1

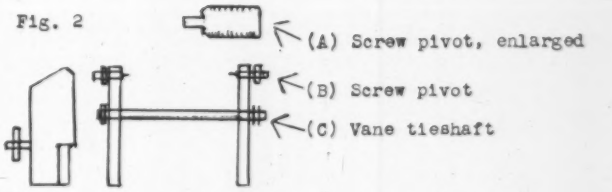

Fig. 2

Fig. 1:—

(A) Jewel setting should be flush or slightly countersunk. Setting shown in cut could be secured with two jewel screws. See plate jewels in watches.
Setting could be made longer and secured by locknut inside.
Setting could be made with a square shoulder on inner end and setting inserted from the inside. (Pushing fit.) This method would probably be the most practical, as it would require the minimum of parts and a straight hole.
Jewel setting should be drilled through with a screw-plug in end in order to facilitate cleaning and to retain a small amount of oil.
Pivots should have a "free bearing" fit.

(B) Pendulum vane tieshaft openings. Their width could control the length of the swing of the vanes and be deep enough to accommodate the crossed vane tieshafts.

(C) Air ducts. Four recommended, connecting rotor housing with lower chamber of pendulous body.

(D) Partition. Thickness determined by the required depth of the tieshaft openings. In order to cast the partition with air ducts and tieshaft openings, it may be necessary to cast the bottom of the pendulous body open; cast cap separate and attach same with screws, similar to method used to attach cap of rotor housing.

Fig. 2:—

(A) Screw pivot, enlarged.

(B) Screw pivots in place with locknuts.

(C) Vane tieshaft. A practical manner to attach would be to thread each end of the shafts, also the vanes, and secure with locknuts. This method would permit easy adjustment of the relative angle of the vanes and also the width between the vanes. One shaft must be lower.
Owing to lack of friction and no loss of air through the bearings this model may act too quickly. If so, shift bearings in vanes nearer the center line of air vents. Air leaks: Two holes drilled in upper air chamber 180° apart, would also slow the action.

C.A.A.-developed Portable Flutter Recorder

WASHINGTON, Aug. 15—A portable flight vibration recorder easily and quickly installed for studying airplane vibration and flutter during flight, has been developed by the C.A.A. and is now available commercially.

The self-contained instrument is light enough to be held on the lap of an observer, and can be installed and put into use within half a day. It was developed by the Aircraft Development Section of the Technical Development Division, and is being manufactured by the Brown Instrument Company of Philadelphia.

The new recorder does not replace the more elaborate and complicated equipment already in use for studying flutter in planes. Its value is in its small size and ease of installation, making possible rapid re-examination of doubtful studies, and many more tests in difficult cases.

Flutter can be, and in most cases is, avoided in designing planes. Especially in large planes, it rarely appears in the first model, in any severe form. Sometimes it appears in a

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particular plane after months of use where it did not exist in the prototype. By using the new recorder, a velocity or acceleromoter type pick-ups can be placed at many places about the structure, and two of these can be operated simultaneously. By using a selector switch, many locations about the plane can be studied in the same flight. The recorder contains its own batteries, amplifier, electronic switch, cathode-ray tube and a means for observing the record on a screen. There is also a camera to photograph the oscillograph record.

For exhaustive flutter study, equipment weighing between 300 and 500 pounds previously has been used. Installation and tests by this method required about two weeks. Frequently, after the equipment was removed, additional information was needed during analysis of the observations. The new recorder is ideal for such re-examination.

The smaller instrument is useful in studying vibration anywhere about the plane, such as in motor mounts, cowling and small accessories, where its ease of installation as a special-purpose instrument is important.

Present knowledge of flutter has been built up over years, and has been gathered from experiments on the ground and in flight. Vibrating machines are still used to simulate flight conditions on the ground. In a few cases, radio-controlled planes have been used with recordings transmitted to the ground during flight, and test pilots have flown planes equipped with recorders which transmit their reports by radio to the ground. For all of these methods, the new recorder is a valuable auxiliary.

Multiple-camera Control Problem Reported Solved

NEW YORK, August 25.—Not only are aerial photographs taken from U. S. warplanes at speeds up to one per second in a fully automatic operation, but as many as seven of the big aerial cameras are operated in synchronization by one controlling device, according to the Fairchild Camera & Instrument Corp., manufacturers of aerial cameras and the instruments which control them.

The demand for new photographic speeds came with the increase in speeds of Army and Navy planes. Prior to the war, the Fairchild company built its intervalometer—the device automatically operating aerial cameras at predetermined intervals—with a range from six to 75 seconds. That is, photos could not be taken at intervals of less than six seconds, nor of more than 75 seconds, when a camera was hooked up with the intervalometer.

With the need for more speed, the Army asked Fairchild to provide an intervalometer with a range of one second

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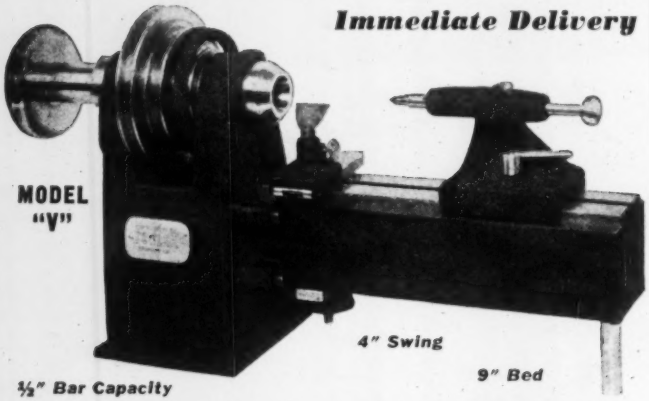

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to 120 seconds. As an answer, Fairchild engineers designed an entirely new unit, which, while smaller and lighter, did about twice as much work as the older model. Not only was the 1-120 second interval range provided but to make the instrument more versatile, additions included: (1) an extra-picture switch button, allowing the aerial photographer to take an extra picture if he happened upon an unusual object that didn't fall within the interval timing, without interrupting the pre-determined scale; (2) a recycle button which also gives the photographer a chance to take an extra picture, but this time starting an entirely new cycle; a counter for the number of exposures; (3) a warning light to show each time the shutter is tripped; and (4) a thermostat-controlled electric heater to provide uniform temperatures for the instrument at high altitudes.

This intervalometer can be installed on the control panel of the plane or any other place handy to the pilot, and thus he remotely operates cameras which may be in the tail.

As the war progressed, the Army began using as many as seven cameras in one plane on joint mapping-reconnaissance missions, and a new controlling device was needed.

It is extremely difficult to operate multiple-camera installations simultaneously, as they include units of widely different focal lengths. As an example, at an altitude of 10,000 feet, when a 6" focal length camera takes pictures, there is a wide-area coverage and a scale of 1/20,000; a 12" gives less area coverage at a scale of 1/10,000; and 24" still less area coverage with the scale 1/5000.

The resulting overlap in the photos didn't provide the same area coverage in any given strip of pictures, so what was needed was a multiple-timing device to provide uniform percentage of overlap in all photos taken from an identical altitude but to different scales.

Fairchild engineers' solution was a camera control unit in which all electric wiring was consolidated in a group of control, impulse and switch units small enough to be put in out-of-the-way sections of a plane, with one control box in the installation providing for pre-set interval timing of photographs for all cameras.

Woman at War*

I'm just the mother of four small dears
Who thought the four would fill the years.
Now I've discovered to my surprise
That world events planned otherwise.

Our "rugged oak" serves Uncle Sam
And I must be both Ma and Man.
But that's not all, oh dear me no!
I have Dad's business to run. And so

It's up each morn, change, feed the babe,
Get the breakfast. Where is a maid?
It's down to the Shop, see morning's mail
And back again to the diaper pail.

It's things to buy, clothes, food and meat
Coupons and ration points, shoes for small feet.
It's gas rations, 'phone calls and priorities,
Bank notes and "forms" for U. S. agencies.

It's sewing and cleaning that's left undone;
Employees to check-up, no time for fun.
But our children eat and healthily grow,
These days more mothers have still greater woe.

For one thing I'm grateful, the service gal knows;
My war job permits my own choice of clothes.
On Dad's return I'll be doubly blest,
With only four children I'll get a good rest.

LOIS LEONARD ENGELHARD

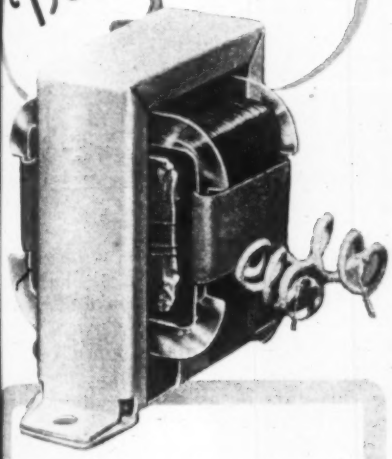
*NOTICE sent to business papers, etc., May 26, 1944:—

This is to advise that William E. Engelhard, proprietor of Pyrometer Service Co., will sell his fixtures, business, goodwill, and trade name of Pyrometer Service Co., to LOIS L. ENGELHARD. Transfer of title is to be made on July 1, 1944, at the Law Offices of Ford and Savona, 1 East Mercer St., Hackensack, N. J., Attorneys for the said William E. Engelhard.

PYROMETER SERVICE CO.
William E. Engelhard

FOR CRITICAL
AC OPERATED
INSTRUMENTS

Bridge Transformer



- Two-winding transformer designed specifically for source input to A.C. bridges.
- Primary, 110 volts 50 to 1000 cycles. Secondary, 75 volts, 15 milliamperes.
- Secondary winding so constructed that there is an air space between core and primary winding. This minimizes capacitance to ground. Electrostatic shield over primary is grounded to core.
- Suitable for power transformer in delicate electronic instruments in which external pickup, particular power line disturbances, must be minimized.

● To meet the critical performance standards set for our A.C. bridges, we have had to develop and build special power transformers. Hence our Type T Bridge Transformer. It has a definite place in many other critical electronic assemblies. We therefore make it available to other instrument-makers. ● Write for literature. Let us quote on your requirements.

Industrial Instruments:

PLANT and OFFICES:
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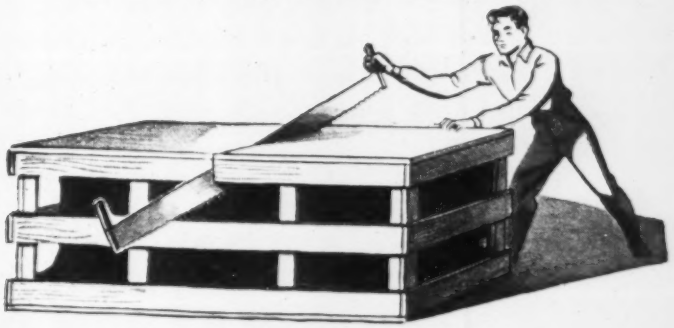
JERSEY CITY 5, N. J.

For faster handling by AIR EXPRESS



divide bulky shipments

into smaller units

THE handling, loading, and unloading of AIR EXPRESS shipments is a speedy operation. Crews are well-trained and skillful. They know and appreciate the importance of making connections, quick delivery. That is why a big bulky shipment that *could* have been broken into smaller units is a disservice to shipper and receiver alike. It simply cannot be handled with the same speed given to ordinary shipments. So to expedite your own shipments be sure they're made up in easily-handled units whenever possible.

A Money-Saving, High-Speed Wartime Tool For Every Business

As a result of increased efficiency developed to meet wartime demands, rates have been reduced. Shippers nationwide are now saving an average of more than 10% on Air Express charges. And Air Express schedules are based on "hours", not days and weeks — with 3-mile-a-minute service direct to hundreds of U.S. cities and scores of foreign countries.

WRITE TODAY for "North, East, South, West"—an informative booklet that will stimulate the thinking of every executive. Dept. PR-9, Railway Express Agency, 230 Park Avenue, New York 17, N. Y., or ask for it at any local office.

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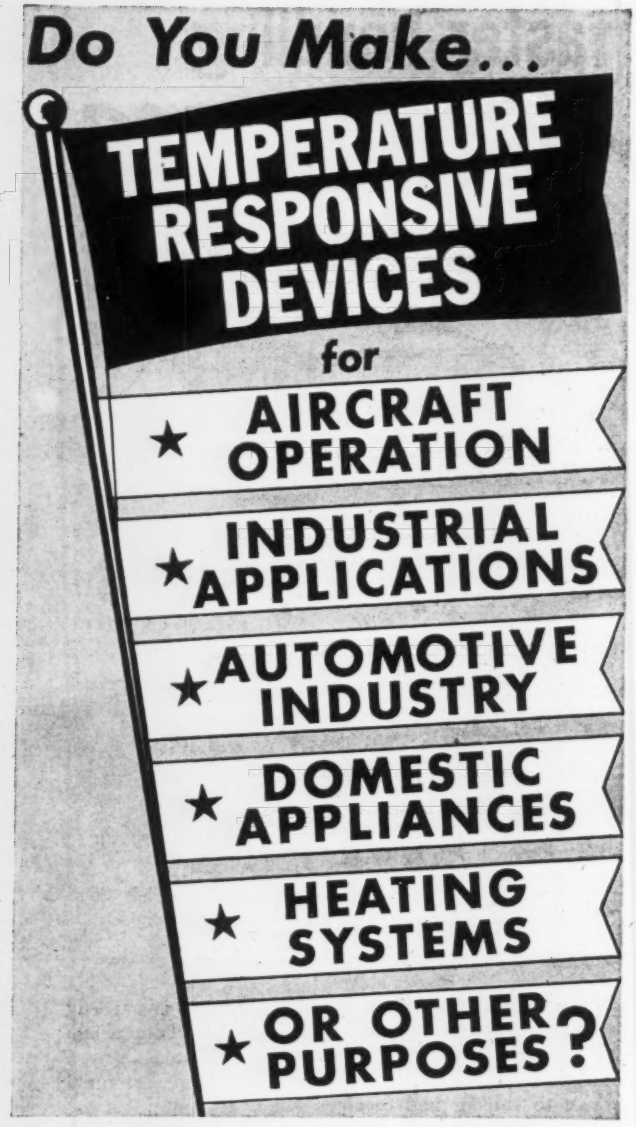

If you make temperature responsive devices for any purpose, then some one of the 35 different types of Chace Thermostatic Bimetals will exactly meet your needs for the actuating element. Each type of Chace Thermostatic Bimetal is especially engineered to meet specific conditions . . . each will produce known action at a predetermined temperature . . . all are very economical . . . and always dependable.

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W.M. CHACE CO.
Manufacturers of
Thermostatic Bimetals and Special Alloys
1609 BEARD AVE • DETROIT 9, MICH.

(Continued from page 535)

metallic separators. These springy separators hold the plates apart normally, but when pressure is applied causes the effective area of contact to change as the pressure changes. The construction is illustrated in Fig. 66C.

Electrolytic gages have not been widely used, but for special applications they have decided advantages. Their operation depends upon the fact that an electrolyte has a resistance whose value can be varied by changing either its length or cross-section, just as with a metallic element. Displacement of the electrodes requires little force, however, since the liquid does not offer resistance to their slow movement; strain in a liquid is not accompanied by stress.

Fig. 68A shows one form which has been constructed for use as a strain gage; it comprises a pair of electrodes in a bath of electrolyte with a third movable electrode between

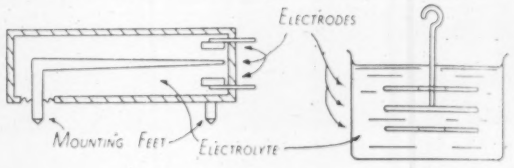

Fig 68

them. The movable electrode is attached to a bell-crank arrangement which converts the strain to a displacement of the central electrode. Electrolytic devices have also been employed (on a larger scale) to detect the movements of balance beams; such an element is diagrammed in Fig. 68B. The devices in Fig. 68 can, like the others described, be connected either as rheostats or as voltage dividers, or as push-pull or resistance-ratio gages.[150,151]

A special form of the electrolytic measuring element is used as a position-locating device in two-dimensional fields. For mapping electric fields between two electrodes, for example, a shallow tray of electrolyte has current electrodes placed within it, and an exploring electrode is then employed to follow the equipotential lines throughout the space between the current-carrying electrodes. The method can be extended to three-dimensional fields, within limitations.

Electrolytic resistance elements may have other characteristics fitting them to special applications. Some, for example, are essentially rods coated with hygroscopic salts, sensitive to changes in humidity; these are used in meteorological instruments, notably in radio-sondes.[152] Others are highly sensitive to temperature changes (thousands of times more so than any metallic element); such thermosensitive elements are likewise used in meteorological research and in temperature control as well.[153] It is a disadvantage of most electrolytic elements that they are sensitive in general to more than one phenomenon, so that they must be judiciously applied if they are to be trustworthy. Occasionally, however, the electrolytic principle can be applied more directly and more effectively than any other, as in the flowmeters which employ the water being metered as its own gaging element; such a device employs two electrolytic electrode assemblies, one completely immersed at all times, the other immersed to an extent dependent upon the water level.[154] The ratio of the resistances of the two electrode assemblies then will represent the water level, no matter how the composition of the water may vary.

Moving-contact elements are among the most robust in

(150) A. Thum, O. Svenson, and H. Weiss. Neuzeitliche Dehnungsmessgeraete. *Forschung auf dem Gebiete des Ingenieurwesens*, Vol. 9, 1938, pages 229-234.

(151) F. S. Eastman. An Electromagnetic Balance for Force Measurement or Current Control. University of Washington Engineering Experiment Station Bulletin No. 60, April 1932.

(152) Harry Diamond, W. S. Hinman, Jr., F. W. Dunmore, and E. G. Lapham. An Improved Radio-sonde and its Performance. *Bureau of Standards Journal of Research*, Vol. 25, 1940, pages 327-367.

(153) P. G. Weiller and I. H. Blatz. Electronic Thermometer. *Electronics*, Vol. 17, July 1944, pages 138-139.

(154) Anon. The "Shotter" Electrolytic Flow-meter. *The Electrician* (London), Vol. 89, 1922, pages 209-211.

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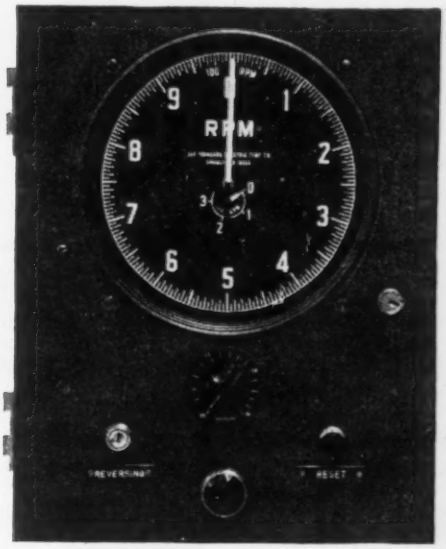

CONTROL UNIT

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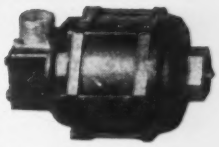

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Cutout closes or opens an electrical circuit (or circuits) at a preselected speed. After tripping it must be manually reset before circuit can be restored.

Accuracy: Tachometer ± 10 RPM for range 200 – 3500
Cutout ± 50 RPM for range 2000 – 3500

Adjustment: Cutout speeds selected on dial graduated each 100 RPM

Cutout can be mounted within chrono-tachometer case or as separate unit as desired.

Write I-24

THE STANDARD ELECTRIC TIME CO.
"Split-Second Measurement by Standard"
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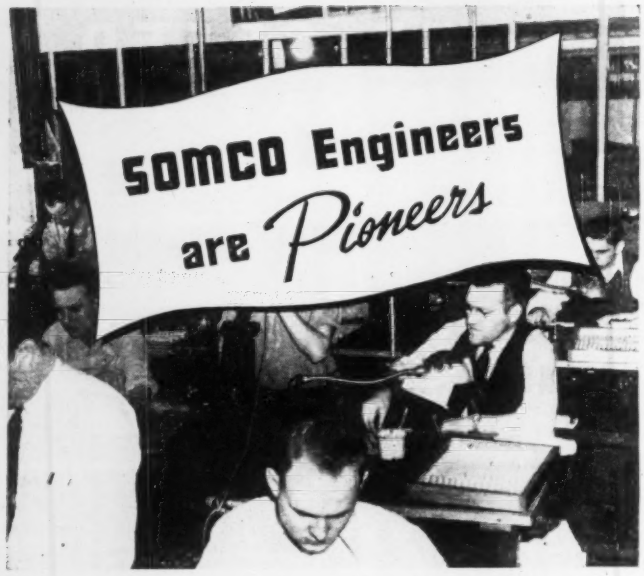

View of hand finishing section of the roof prism department

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construction and simple in operation of all electric gaging elements; their principal disadvantage is that extremely small movements cannot well be measured through the motion of a sliding contact. For movements as great as a tenth of an inch they can be satisfactorily applied. They can be given almost any desired calibration characteristic and they can ordinarily provide sufficient current output to operate indicating instruments without added amplification.

§ 3. Thermosensitive Resistance Elements.

When a mechanical magnitude is to be measured with a thermosensitive element, it is necessary that that magnitude first be converted into a change of temperature: the resulting change in temperature can then be measured in the same manner as any other such change.

Every electrical conductor experiences some change in resistance with change in temperature; the percentage change per degree (usually Centigrade) is its temperature coefficient of resistance. Gaging elements for measuring phenomena other than temperature changes, therefore, must be so constructed mechanically as to convert the mechanical magnitude into a change in temperature of the resistance element. Since it is necessary at the same time to exclude other effects which might produce spurious indications, or to compensate them, the characteristics of the resistance material are sometimes secondary in importance to the mechanical design of the element.

Although the devices described here are listed as variable resistance instruments, their changes in resistance are caused by changes in temperature of some part of the gaging element. Usually such a change in temperature is the result of a change in rate of heat transfer from an element which is supplied heat at a constant rate; therefore the mechanical design must involve principles of heat transfer.

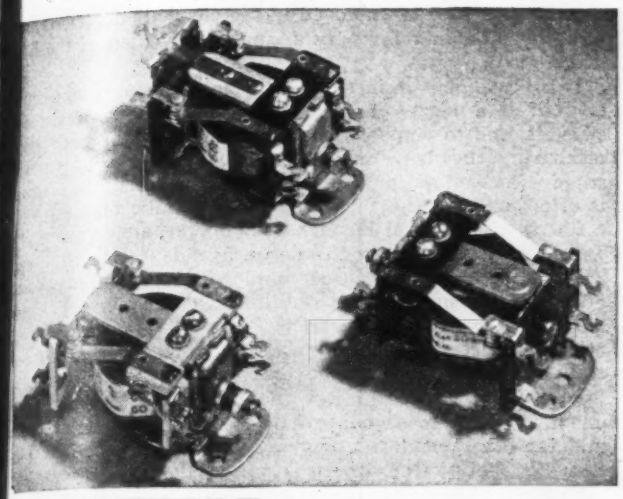
Heat transmission is a subject which, while appearing relatively simple, is actually a complex and involved one. The classic headings under which methods of heat transfer are placed are conduction, convection, and radiation, but instances in which only one of these principles apply are seldom encountered in practice. Instead, two, or even all three, of the basic methods operate simultaneously.

Transmission of heat by molecular motion, through a medium not necessarily permeable to radiation, and not fluid or otherwise movable, is termed *conduction*.

Transmission of heat by particle or fluid motion, in which the fluid material takes on heat energy by contact (conduction) or otherwise, then is transferred to another location at which it loses its heat, is termed *convection*. Such transmission ordinarily involves another method of heat transfer by which the heat is imparted to the fluid at one end of its journey and is removed at the other. Transfer of heat energy through electromagnetic waves is termed *radiation*.

In general, it may be stated that where molecular concentration is very high (solid matter, liquids, gases at high pressures) heat transmission by conduction is efficient. Where an intervening material is mobile or fluid, convection can take place. Where molecular concentration is very low, as in rarefied gases (or in interstellar space) radiation provides the only means of heat transfer. In a mechanical assembly all three methods may operate simultaneously; in an electric bulb, for example, heat is radiated from the filament, conducted down the supporting wires to the base and also outward through its atmosphere if the bulb is a gas-filled one, and—while little convection occurs within the bulb—its outside is cooled by the flow of ambient air.

The laws describing heat transfer are in some respects analogous to those describing the flow of electric current. Increase of thermal *conductance* is accomplished either by increasing thermal *conductivity* or by decreasing the length of path. For a particular situation the rate of heat transfer depends upon the temperature difference (potential) as well as upon the conductance of the path. One effect not represented in the electrical analogue is that due to surface conditions: light-colored, polished surfaces neither radiate nor absorb as readily as dull, dark ones. Another difference is that the rate of heat transfer by radiation increases much more rapidly than the temperature of the hot body; at the



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ARMY NAVY

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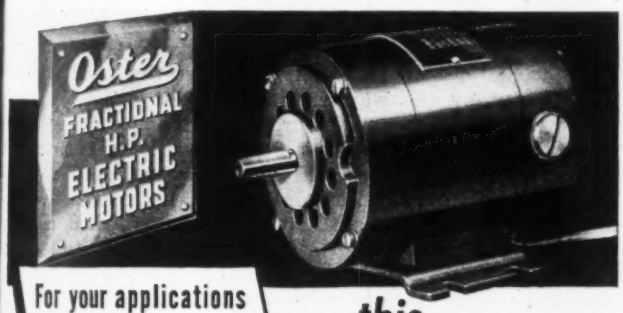

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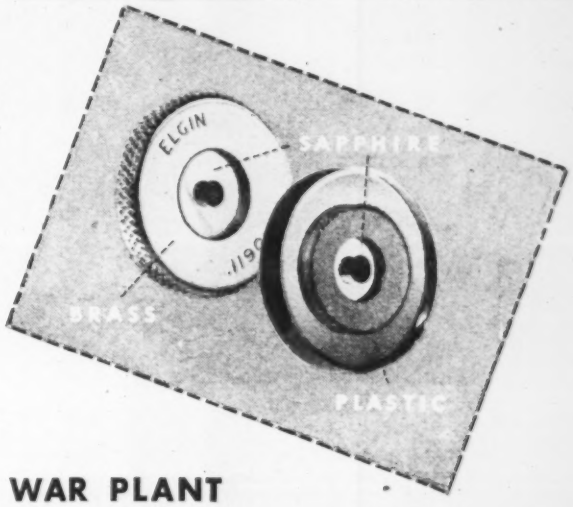

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lower temperatures employed in the elements described here radiation accounts for only a small proportion of the heat transferred.

It is convenient in most applications to employ an electric current as a means of introducing heat into the resistance element, and to employ the same current in the resistance measuring means. For the sake of economy of current supply (as well as for other reasons) the resistance element is often made in the form of a fine metallic filament, only a few thousandths of an inch in diameter, and is suspended within an atmosphere of some gas.

A simple device for measuring low gas pressures consists of a pair of bulbs each containing a fine wire filament, one bulb having been exhausted to a fair vacuum and the other connected to the chamber in which the pressure is to be measured. (The author has used low-wattage electric lamps for pressures of less than two inches of mercury, one fitted with a tubulature to permit access of the gas and the other employed unchanged as a reference element. See Fig. 69A.) When there is no gas flow, or only a small flow as in continuous-sampling methods, the loss of heat from such a filament takes place largely by conduction through the gas to the tube wall (and then through the wall to the open air) so that the temperature of the filament will decrease as the gas pressure increases. If the filament material has a positive thermal coefficient, the

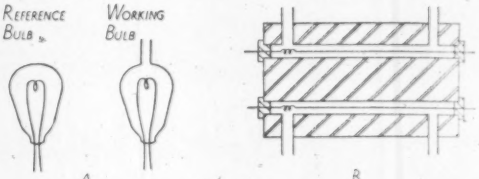

FIG. 69

resistance will decrease likewise. A Wheatstone bridge circuit can be employed to measure the ratio of the resistances of the two filaments; if this ratio is the criterion, changes in temperature of the entire assembly will have little or no effect on the measurement.

In addition to the heat lost by conduction through the gas, some heat escapes by conduction along the supporting wires, some by radiation, some by convection, and some is carried out by the warmed gas if it is allowed to flow through the instrument. In order to minimize these other effects, and to force the heat flow through the path which gives the methods its greatest sensitivity and accuracy, instruments for precise measurements by thermosensitive elements usually employ straight filaments stretched concentrically in small-diameter tubes. Often these tubes are simply holes drilled in a massive metal block. The conducting path through the gas may be as short as 1/16 inch; and the construction is such as to facilitate the transfer and eventual loss of heat to the air. Fig. 69B indicates the manner of construction. In operation, it is customary either to stop the flow of gas during a reading, or to maintain the rate of flow constant at all times.

These devices are chiefly employed to measure or compare pressures of gas of known composition, and for determining the proportions of gaseous mixtures at known pressures. Fuel-air mixture ratios are measured in motor intake manifolds, and motor efficiency is evaluated by similar measurements on the exhaust gases.[155] Humidity can be measured and controlled by instruments employing the principle.[156] Portable instruments are used for detecting gas leaks in balloon fabric, and in large airships containing a number of gas-cells within an outer envelope, automatic alarm devices have been installed.

In the foregoing paragraphs the *thermal conductance* of the gas was the measurement criterion and variations in gas flow were mentioned as sources of error. But when all factors other than gas *velocity* are held constant, this velocity alone determines the cooling rate of the filament,

(155) O. E. Patton. Aircraft Instruments. Chapter 5. Van Nostrand, 1941. 200 pages.

(156) A. C. Walker. Recording and Producing Low Humidities. *Instruments*, Vol. 6, 1934, pages 184-186.

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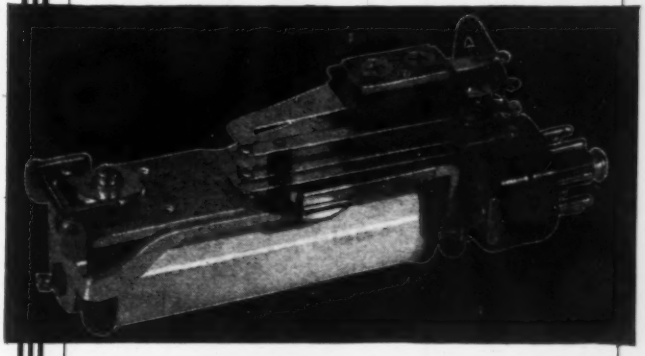

Illustrated above is the Cook Type 113 Relay. This is an A.C. relay with a single pile-up, laminated core, heavy Oilite bearing yoke, special silicon steel armature and heel piece, and plug-in base. Springs are of nickel silver with bakelite insulators baked at 150° for 100 hours.

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and we then have the resistance-type hot-wire anemometer,* many forms of which (with single or multiple filaments) are successfully used—either in conduits or in the open atmosphere.

By installing such a filament in a tube open at both ends, and so mounting that tube as to permit air heated by the filament to flow through it, the velocity of the air-flow will depend upon the inclination of the tube, and the resistance of the filament can therefore be used as a criterion of inclination.[157]

A useful extension of this temperature-sensitive filament principle is applied to acoustic measurements; one form so used is shown as Fig. 70A. The instrument is called a hot-wire microphone, and employs a resonating chamber in the neck of which is placed the grid or filament. Acoustic waves

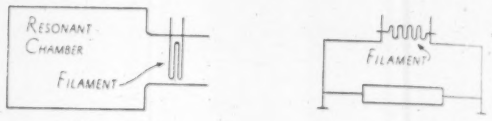


FIG. 70

of the frequency to which the resonator is tuned will produce a vibratory movement of the air through the neck of the resonator, and the cooling effect of this moving air will be in proportion to its velocity.[158]

The principle is also applied to the measurement of earth movements or other vibrations; a form used for such measurements is shown in Fig. 70B. In this pick-up a flexible diaphragm carrying a mass is the moving element; its inertia maintains its position relatively stationary compared to the case surrounding it. Through the neck of the case, in which the heated filament is placed, the air is forced at a rate proportional to the velocity of the movement.[159]

Other forms have been developed which are capable of measuring mechanical movements directly; like those already described they depend upon the transfer of heat from a filament to the atmosphere or to some other element. One such is the Shakespear hot-wire micrometer.[160] This instrument usually employs four helical coils of fine wire, connected electrically to form a complete Wheatstone bridge circuit, and arranged mechanically so that the movement being measured increases the length of two of the coils and decreases the length of the other two. The rate of heat loss from such a coil depends upon its effective area; it increases as the length of the coil (and the spacing of the adjacent turns) increases. The instrument, drawn in Fig. 71, can provide a magnification as great as 1,000, indicating on a robust pointer-type instrument.

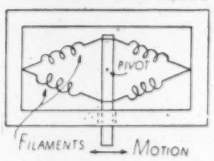


FIG. 71

In this instrument, the heat lost by the helical filaments is conducted through the confined air to the metal enclosure, and there dissipated to the outside air; to facilitate this heat transfer the interior surfaces are blackened.

The instrument has been used for the measurement of strains for movements of various kinds. One interesting installation was in the British rigid airship R-101: instru-

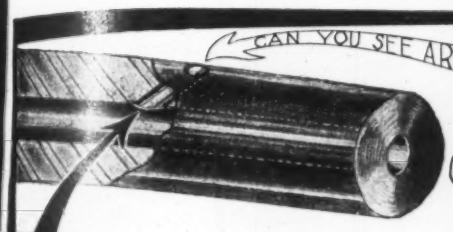
*The other type of hot-wire anemometer or flowmeter is the one in which the temperature of the filament (and hence its resistance) is kept *constant* by varying the heating current as the flow (and hence the cooling-rate) varies. A wattmeter (or properly-applied ammeter) then serves to indicate or record the gas flow-rate.

(157) P. A. Borden. Electrical Measurement of Physical Values. *Transactions American Institute of Electrical Engineers*, Vol. 44, 1925, pages 238-263.

(158) W. S. Tucker and E. T. Paris. A Selective Hot-wire Microphone. *Philosophical Transactions of the Royal Society* (London), A, Vol. 221, 1920-1921, pages 389-430.

(159) A. B. B. Edge and T. H. Laby. Principles and Practices of Geophysical Prospecting. Chapter 5. Cambridge University Press, 1931. 360 pages.

(160) E. B. Moss. Shakespear Hot-wire Micrometer. *Journal of Scientific Instruments* (London), Vol. 7, 1930, pages 393-396.



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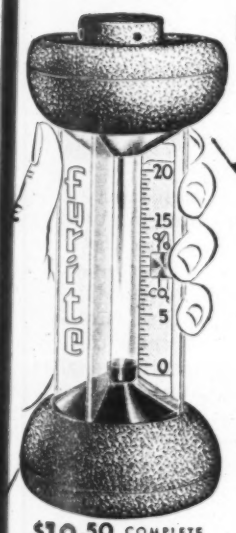

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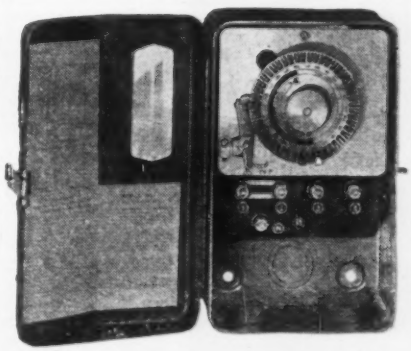

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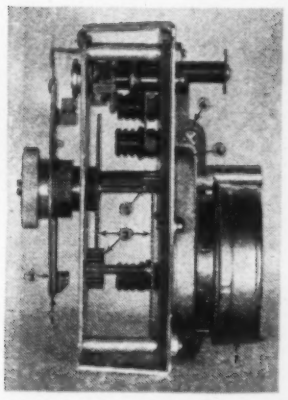

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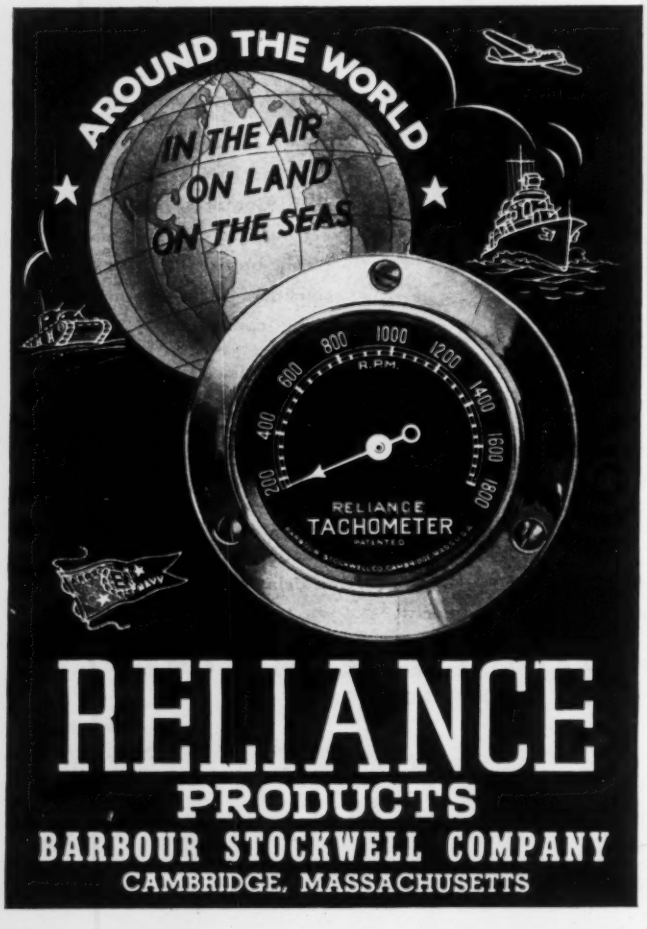

ments were installed to measure stresses in the [illegible] of the dirigible and in other parts, and to measure [illegible] record the tension in the mooring cables.[161]

Another form of hot-wire instrument has been effectively applied to the amplification of the signals received over submarine telegraph cables. The extremely weak currents transmitted over the cable are passed through a sensitive pointer-type galvanometer, to the pointer of which is attached a fine platinum filament. This filament is stretched between two stationary filaments, each one closely adjacent to half the movable filament. The plan of the instrument is shown in Fig. 72. Either the central moving filament or the two outer stationary filaments may be heated. As the filaments are moved nearer to each other, heat is transferred more rapidly from one to the other; thus if the filaments are connected in a Wheatstone bridge circuit their change in resistance will produce a change in the output current. The current output is sufficient to operate a recording device, and its response is rapid enough to follow the signals carried by the telegraph cable.[162] In this application, the instrument is usually known as the Heurtley hot-wire magnifier. It has the distinction of being one of the few devices which can be successfully attached to the pointer of a sensitive galvanometer.

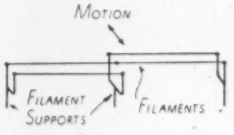

Fig. 72

The same general principles must be fulfilled with all devices employing the principle of heat transfer to or from a thermosensitive resistance element. Since the change in resistance of the element occurs as a result of a change in its temperature, the design of the assembly must be such as to eliminate or minimize errors from changes in the temperature of the surroundings. Satisfactory accomplishment of this requires consideration of many factors.

Errors caused by thermal instability—change in temperature of the sensitive element from causes other than the unknown phenomenon being measured—may be reduced to a negligible figure by incorporating all four arms of the Wheatstone bridge circuit in the gaging element itself. Or, if a single filamentary resistance is exposed to the varying temperature, another may be used as the reference element; the third and fourth arms of the bridge may then be made of material having a thermal coefficient so low as to make them unaffected by ordinary temperature changes.

It is ordinarily more accurate to measure the current required to maintain the filament temperature and resistance constant than to measure the change in resistance. But if only one filament can be installed, so that no reference element is available, no correction for ambient temperature changes is possible. Accuracy then is made highest by employing as high as possible filament temperatures, and a Kelvin bridge circuit to measure the filament resistance. This circuit, as well as others, will be described in the appropriate section.

The material of which the filamentary resistance elements are made must likewise fulfill certain requirements. It must have a high thermal coefficient of resistance (both sensitivity and accuracy are affected by this characteristic) and it is desirable that it also have a high resistivity; it will then require a smaller current for heating purposes. It must be ductile, since it is used in the form of fine wire; and it must be non-corrodible and non-oxidizable, since it is maintained in air for long periods of time at elevated temperatures.

The history of the method indicates that the best results have been obtained with platinum filaments (tungsten, though more difficult to fabricate, is likewise satisfactory) and with operating temperatures of about 200°C. Higher operating temperatures increase the sensitivity, and decrease errors from ambient temperature changes, but intro-

(161) Anon. The Shakespear Hot-wire Micrometer on the R-101. *Engineering* (London), Vol. 129, May 2, 1930, pages 584-585.

(162) Harold Pender and Knox McIlwain. Electrical Engineers' Handbook: Electric Communication and Electronics. Section 11. John Wiley and Sons, 1941.

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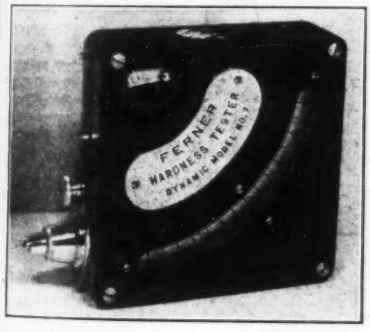

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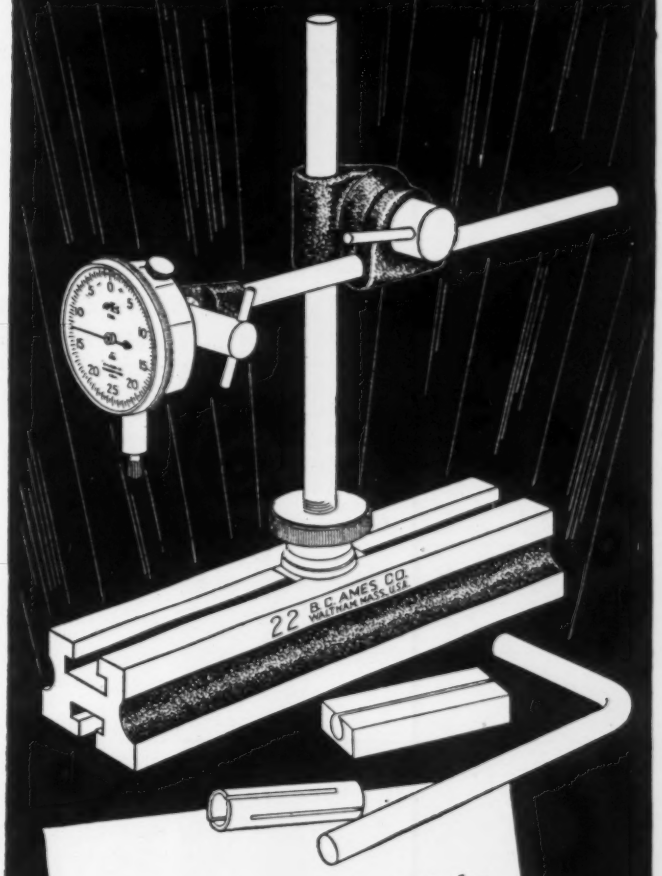

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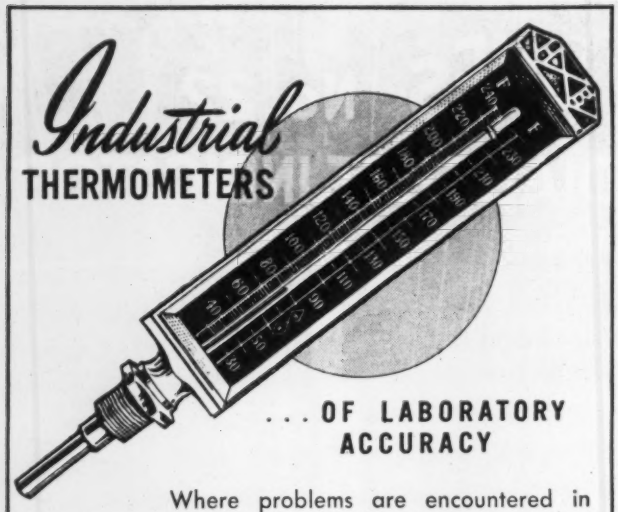

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duce other difficulties which counteract these advantages. In some applications, however, temperatures as high as 1000°C. have been satisfactorily used.

Modifications of the method have also been employed wherein the resistance elements are immersed in a liquid; the rate of cooling is of course much greater than when the unit is surrounded by air. Protective waterproof sleeves or coatings are used to keep the resistance wire from being damaged by exposure to the liquid. Such units are most often employed to detect the presence of a liquid, or to measure its depth in terms of that portion of a long resistance element which is actually immersed.

Thermal elements have in operation several disadvantages; they are less robust and less accurate in use than others, and they have inevitably a time-lag in their operation. Their upper limit of frequency response depends upon the thermal capacity of the element; seldom is it higher than a few hundred cycles per second. They have, however, the advantages of simplicity of construction and of operation, and they require no amplification. For measurements of density, pressure and composition of gases they are unequalled; for measurement of velocity of gases they are likewise invaluable. No other gage is available which can be installed to measure the velocities of air in small turbulent patterns.

Special-purpose devices of this sort are widely used for gas-metering and similar applications. No detailed descriptions will be given here; they are fully described in the literature.

To be continued

Electron Tube Principles

Continued from page 533

through the wires of the screen wires do so with a velocity corresponding essentially to the screen potential.

Fig. 164 shows the structure of a typical beam power tube, i.e., that of the 6L6. This shows how the electrons are confined to beams. The screen and the grid are spiral wires wound so that each turn of the screen is shaded from the cathode by a grid turn. This alignment of the screen and grid causes the electrons to travel in sheets or beams

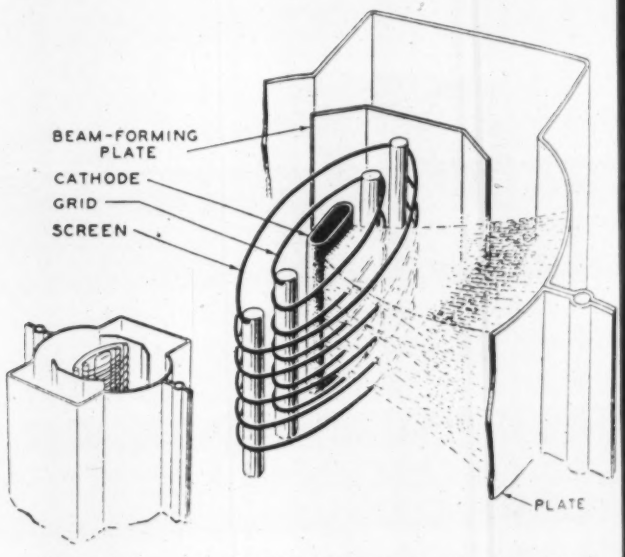

Fig. 164. Structure of a typical beam power tube, i.e., that of the 6L6.

between the turns of the screen so that very few of them flow to the screen.

In Fig. 164 the beam condition illustrated is that for a plate potential less than the screen potential. The high-density space-charge region is indicated by the density of the dashed lines representing the electron paths. Note that the edges of the beam-forming plates coincide with the dashed portion of the beam and thus extend the space-charge potential region beyond the beam boundaries to

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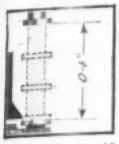

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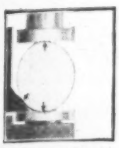

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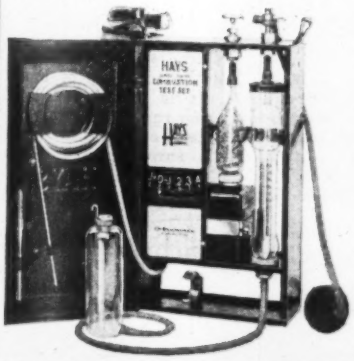

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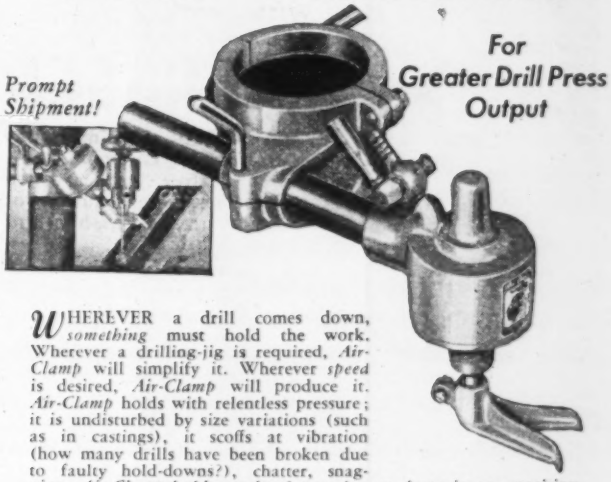

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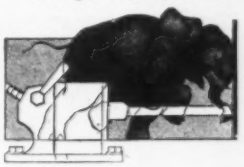

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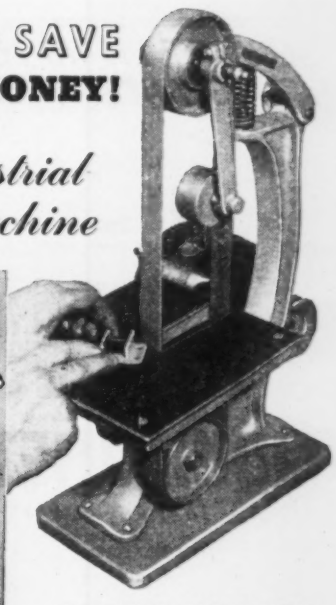

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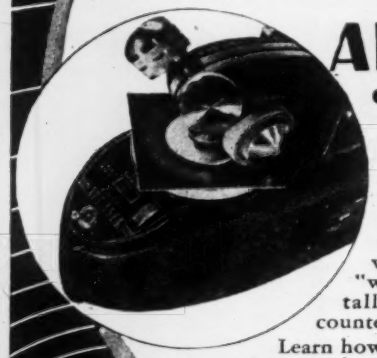

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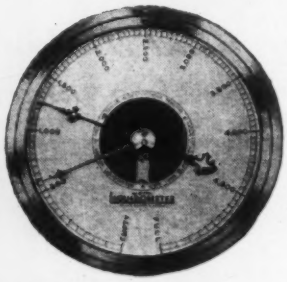

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prevent stray secondary electrons from returning to the screen outside the beam. The flattened cathode gives a much more uniform and larger effective area than a round cathode.

So much for the beam power tube at this point. It was introduced here because it is a special type of pentode and should be listed as a separate class in any classification of tubes.

There are other types of tubes used in ultra-high-frequency work, very complex in their workings, which will not be discussed at this point. These few examples will serve to show that an almost endless variety of combinations is possible and that as the need for other combinations of functions arises, new tubes can be devised.

Tubes are also classified regards their characteristics. There are, for example, sharp-cut-off and variable-mu (μ) types. In the sharp-cut-off type of tube, the amplification factor* is practically constant regardless of the grid bias, while in the variable-mu type the amplification decreases as the negative bias is increased.

The principal point I want to emphasize in this article is that the complexity inherent in modern tube data need not cause discouragement to the beginner in electron tube work. For most industrial applications only a few simple types are used and they are involved in relatively simple

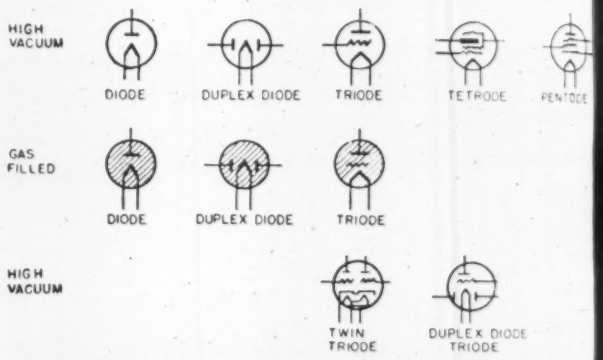


Fig. 165. The most commonly used electron tubes.

circuits. The types of tubes indicated in Fig. 165 are all that the average industrial user need be concerned with and some of these will find application only rarely. One should, however, be familiar with different tube types and their characteristics and one should study the tube data from time to time as they are released. For general information, the Radio Corporation of America publishes a tube manual which sells at a low price and presents up-to-date data on the most commonly used tubes. A great amount of information is available in various handbooks, and a dozen or more good books are available which deal with tubes in various ways. No attempt will be made in this series to present detailed data on tube characteristics as that is all easily available elsewhere.

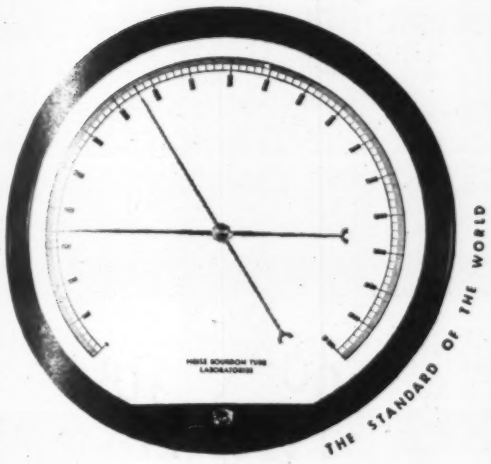
To be continued

*The amplification factor of a tube is the measure of the amplification of which a tube is capable. It is designated by the Greek letter mu (μ) and is expressed as the ratio of plate voltage change required for a given change in plate current, to the grid voltage change necessary to produce the same change in plate current.

Wright Aeronautical Nitriding Furnaces

By J. A. SCHNEIDER, Application Engineer, Westinghouse Electric & Mfg. Co., Cincinnati, Ohio

A LARGE nitriding furnace installation (believed to be the largest in the U. S.) recently made at the Ohio plant of Wright Aeronautical Corp. consists of 58 Bell type furnaces used for nitriding aircraft engine cylinders and internal gears. This new type nitriding furnace has reduced the ammonia consumption by over 50%. Furthermore, the uniformity of hardness and case depth is exceptionally close.



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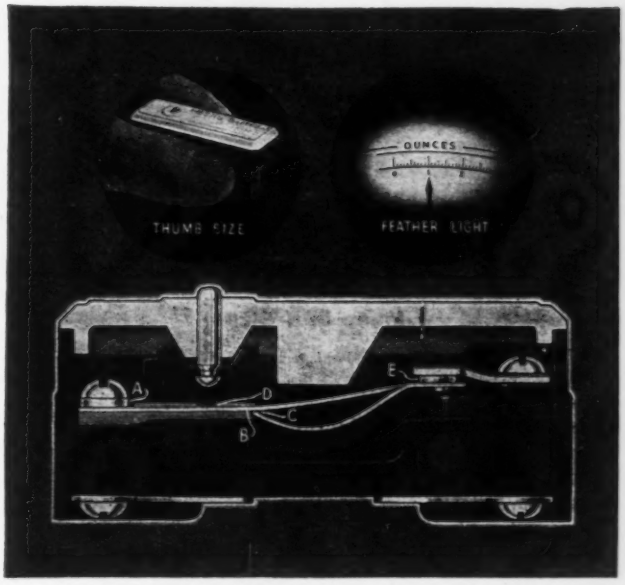

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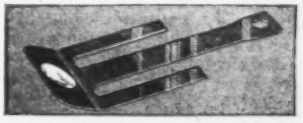
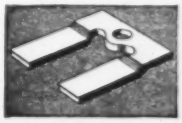
The Micro Switch design incorporates features that provide desirable performance characteristics not generally found in snap-action switches . . . The heat-treated beryllium-copper spring bends in the same direction as the operating plunger—no reverse bends—no "oilcan" action . . . gives longer switch life—accurate repeat action—increased contact pressure—lightning-fast action—millions of operations on minute movement and force differentials. It is the choice of design engineers for all types of sensitive instruments.



The beryllium-copper spring is made in one piece. It is gauged to an accurate .0085" thickness; has high resistance to fatigue. Ends of compression members are finished to provide an extremely low friction bearing. Contact end of the spring is fitted with a riveted radius type contact of 99.95% fine silver. It moves at a speed of 3/1000ths to 5/1000ths of a second with a rolling action and extremely high pressure.



Short spring members pivot in patented V-grooves of this sturdy brass anchor. Note the special shape of these grooves, which reduces friction to a minimum.

Stationary contact is a flat inlay of 99.95% fine silver. This construction assures ample over-load capacity and maximum heat dissipation.

Operating plunger is a highly polished stainless steel pin imbedded in an accurately moulded star-shaped Bakelite head. Provides long over-surface path to live parts, thus insuring freedom from electrical leakage. Plunger head cannot rotate within the housing, insuring against any variation in point of operation.

If you would like to know more about the Micro Switch, send for the two Handbook-Catalogs illustrated here—No. 60, which covers Micro Switches in general; and No. 70 which deals with specific Micro Switches for use in aircraft.

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Micro Switch is a trade name indicating manufacture by Micro Switch Corporation

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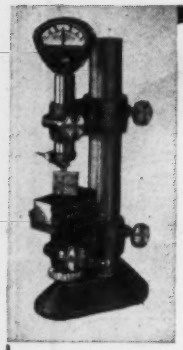

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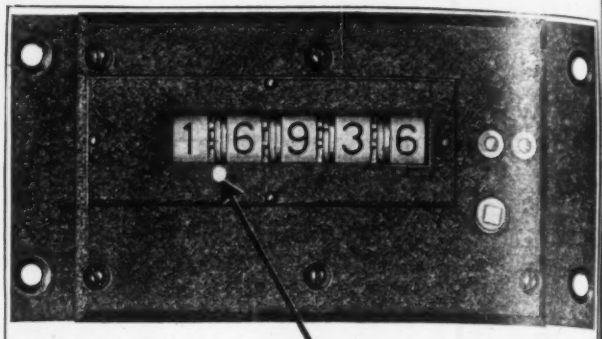

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Quick reading, trouble-free, accurate, dependable.

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"Instrumentation Comes of Age"

(Continued from page 525)

neering school course of study, or its equivalent in training or experience, subject to the approval of the lecturer.

The course is given in the form of lectures with class discussion and class problems in the design and calculation of instrument components. *Outline:* Introduction; Theory of instruments; Geometric design; Vibration effects, damping; Springs, mechanical movements; Bearings and jewels, lubrication; Electromagnets, solenoids, permanent magnets; Relays, interval timers, contact materials; Temperature compensation; Materials used in instruments; Electrical components; Photocells, v-t. amplifiers; Fractional h-p. motors, motor controls; Optical components of instruments.

* * *

A two-evening-a-week course in Electronic Control is being given by the School of Engineering, George Washington University, Washington, D.C. It began on Sept. 4 and will end Dec. 15. Conducted by R. C. Darnell, it is a general descriptive course in the principles and applications of electronic devices in industry; and is intended for service and maintenance engineers and others designing or using electronic equipment as required for the war effort.

This is an ESMWT course sponsored by the U. S. Office of Education, tuition free to qualified students: two years of an engineering school course of study and an elementary radio course, or their equivalent in training or experience, subject to the approval of the lecturer.

* * *

University of Pittsburgh

A booklet entitled "Graduate Work in Industry" describes courses for 1944-45 arranged by the University with affiliated companies. These courses carry credits, but candidates must supplement them with campus instruction under the resident faculty. Fall semester starts Monday, Sept. 25. Registration, Sept. 21-23 (phone for details if interested). Some of the courses of interest to *Instruments* readers are:

Ext. 241, 242. Process Engineering Instrumentation. A comprehensive course in the theory and application of basic instrumentation control to chemical processes. The instrument mechanisms, pneumatic, hydraulic, and electrical will be considered during the first semester. This will be followed by the applications of the various types of commercial units to industrial practice. First and second semesters. Two credits each semester. Tuition $20 a semester. Thursdays, 7:00 to 9:00 p.m., Westinghouse Educational Center, Wilkinsburg.

E 105, 106. Treatment of Experimental Data. (Recommended as a possible tool of research.) Three credits each semester. Tuesdays, 7:00 to 10:00, Thaw Hall.

E 137, 138. Industrial Spectroscopy. Four credits each semester. Mondays 6:05 to 11:00 p.m. Thaw Hall.

E 245. Incandescent Radiation and High-temperature Measurements. First semester only. Three credits. (By appointment.)

W 290, 291. The Conduction of Electricity Through Vacuum and Gases. Two credits each semester. Tuesdays 7 to 9, Westinghouse Educational Center, Wilkinsburg.

W 271. Dynamics and Vibration.
E 161, 162. Fluid Mechanics.
E 121. Time Study.
E 122. Motion Study.
C.S. 151. Methods Engineering.
AL 213, 214. Metallography of Aluminum.
St 107, 108. The Machine Age in American History.
E 133. Petrography.

* * *

Catholic University

A one-evening-a-week course on Electronic Measuring and Testing Instruments at the Catholic University of America, Washington, D. C., began on Sept. 6 and will end on Dec. 17. Conducted by R. C. Darnell, this is an ESMWT course sponsored by the U. S. Office of Education. It is designed for engineers, physicists and technicians using or requiring knowledge of electronic instruments, in connection with war activities. Prerequisite: College calculus and physics.

* * *

Instrument Course Reopened By Brown

PHILADELPHIA, Aug. 21.—First of the 1944-45 industrial instrument maintenance and repair courses of the training school Brown Instrument Co., will start September 25. The classes this fall, according to Earl M. Robinson, manager of the company's service division, will be attended to the largest extent by personnel from customer plants. The course will continue until and including December 22.

* * *

Westinghouse Electronics Course Made Available

PITTSBURGH, Sept. 1. — Consisting of sound slide films, lesson books, quiz books and an instructor's manual, a new ten-part training course on basic principles and applications of electronics in industry has been prepared by Westinghouse. Originally designed for Westinghouse employes, the material has been made available to others at reproduction costs because of many requests from groups and individuals.

It is recommended that twenty hours be allowed for the full 10-part course—two hours for each part, with classes held one night each week, thus giving class members a chance for review and supplemental reading.

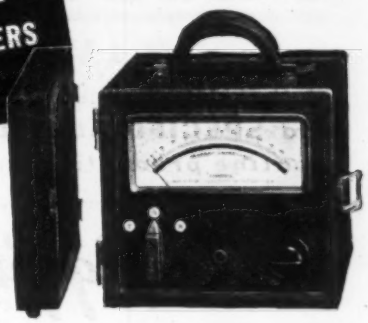
Subjects covered by the course are as follows:

Part I—Electronics and the electron

(Continued on page 584)

Alnor RESISTANCE THERMOMETERS

Type 2900
Portable Resistance
Thermometer



Rugged construction, high torque movement, and long mirror scale provide for consistent accuracy in this Alnor portable electric thermometer. Available in any desired range with a span of 50 deg. F. or more between minus 50 deg. F. and plus 400 deg. F. Also with two or more scales, and multi-point instruments.

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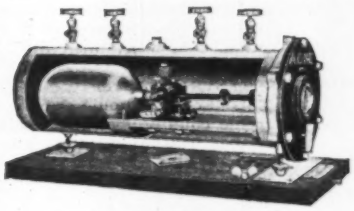

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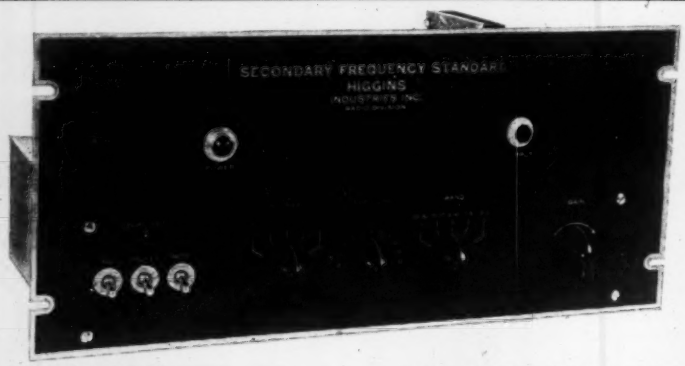

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2—Ample RF output
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4—A crystal stability of at least 1 cycle per megacycle per degree centigrade
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MODEL FS-11:

1—Same as the Model FS-10 except for an additional interval as required by YOUR type of work!

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C-R.O. AS INDICATOR

Continued from page 527

Fig. 11 shows the arrangement of the front panel of the instrument and in using the instrument the following instructions should be noted:

External connections:

All INPUT terminals are on the *left* hand side of front panel.

All OUTPUT terminals are on the *right* hand side of front panel.

Input connections:

Degree marker voltage (from Sunbury "Sweep" Unit) to binding post on top, marked DEG and ground GRD.

Engine contact to *two* binding posts marked ENG CONT.

Pick-up voltage to binding posts HIGH and GRD.

Output connections:

DEG MARK to terminal on *back* of RCA oscillograph.

SYNCH I to binding post SYNCH (high) on RCA oscillograph.

SYNCH II to connection on left side of oscillograph case (i.e., to grid of 885 tube).

OUTPUT HIGH and GRID to RCA oscillograph VERT HIGH and GRD.

Adjustments:

1. Turn POWER switch into position ON. (This should turn the red control light on.)

2. For direct diagram turn knob INTEGRATE GAIN as far counter-clockwise as possible. (No power is necessary for this case and the power switch may be turned off when direct diagram is used for long period of time.)

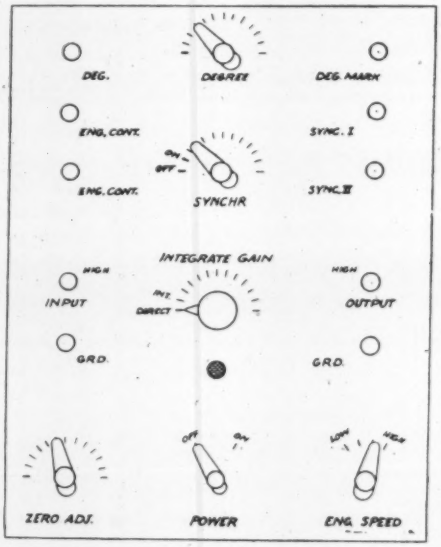

Fig. 11.

For integration, turn knob INTEGRATE GAIN clockwise, first to switch form direction integrated diagram and then for increase in magnitude of figure.

3. ENG SPEED. The knob for engine speed has four positions; HIGH speed is in the clockwise direction. This knob should be in one of the two positions for high speed, the other ones being for low frequencies only.

Caution: If the ENG SPEED is turned too far counterclockwise the figure on the oscillograph may swing vertically. This swinging may increase rapidly if ENG SPEED is not turned clockwise.

4. ZERO ADJ. This knob should be turned as far counterclockwise as possible. If the integration curve does not come back to zero, turn ZERO ADJ clockwise until the right adjustment is obtained.

At low frequencies the figure will swing vertically if ZERO ADJ is turned too far clockwise, indicating over-correction. *Be sure that* ZERO ADJ *is always turned counterclockwise when beginning.*

5. SYNCH. Turn clockwise until figure on oscillograph stands still. At end of work, turn this knob all the way counterclockwise until the switch has turned off the battery inside the unit.

6. DEGREE MARKER. Be sure that this *knob* is always in the extreme counterclockwise position, if full line is desired. For degree marks, *first turn intensity* INT on RCA oscillograph counterclockwise until diagram just disappears. Then turn DEG MARK clockwise, until diagram appears as dashed line.

7. SYNCHRONIZER ON RCA OSCILLOGRAPH. This SYNCH should be turned to the extreme counterclockwise position. In case the dashes run along the diagram line, turn this SYNCH in clockwise direction until dashes stand still.

Remarks:

The synchronizer and the degree marker are entirely independent from the integrator unit. Thus, for use of the direct diagram with pick-up wire connected either through the integrator (and knob INTEGRATE GAIN in

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Askania's Bulletin No. 101 is just off the press . . . it is written for those whose chief concern is the matter of efficiency and accuracy in proportioning liquids or gasses . . . it also contains an Orifice Sizing Chart which is accurate, fast and easy to use.

The Askania method of Proportioning Control has proved itself in some of the nation's major industries. You'll be interested to see how this method is applicable to proportioning problems in the . . . Cement, Glass, Chemical Sewage and Water Treatment Plants . . . Gas Manufacture and Distribution . . . Steam Production . . . and the Iron and Steel Industry.

Write for your copy of Bulletin No. 101 today.

ASKANIA REGULATOR CO.

1605 S. MICHIGAN AVENUE, CHICAGO

MICROPHONES By UNIVERSAL

The recent Army and Navy "E" award to UNIVERSAL is an additional incentive to UNIVERSAL workers who, even previous to Pearl Harbor, have worked day and night to produce microphones for various branches of the Armed Services.

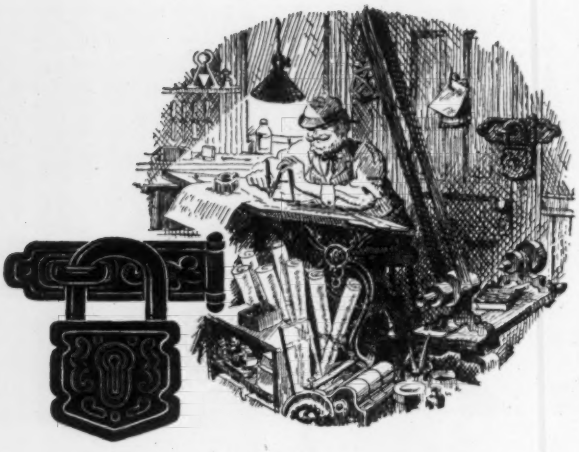
In times of peace, UNIVERSAL produces some 250 different microphone styles. In wartime, mass production has been turned mainly to hand, lip and throat styles, and these are found in every part of the global war doing yeoman service for troops of the United States and Allied Nations.

UNIVERSAL microphones, vital voice communications components, are doing their part to make our soldiers "the best equipped army in the world."

When victory is won, UNIVERSAL again will present the latest engineering designs in microphones. They will be adapted to every conceivable use in which microphones are component parts . . . for inter-factory and office messages, for voice communications on land, air and sea.

UNIVERSAL MICROPHONE COMPANY

INGLEWOOD, CALIFORNIA



The lone wolf theory of design is engineeringly obsolete

THE WORLD AT WAR demands a high degree of precision in its machines of destruction, a degree so high as to be attainable only as a collaborative engineering accomplishment.

THERE IS LESS TIME for individual mental craftsmanship—originality of concept—such as was characteristic in days past. Now, the intellectual as well as the manual product of man's efforts must conform to the principle of the production line.

INTO THE BASIC DESIGN of the engines of war are incorporated *all* things—from *all* sources—which contribute to exacting performance.

HAD THE INSTRUMENTS and devices of control not been available, the engineering feats now being accomplished would not have been possible. Functioning as component parts of modern mechanism, they leave nothing to chance. They measure and control production and performance automatically. They mark the difference between mediocrity and excellence in results.

THE LONE WOLF THEORY of design is engineeringly obsolete. Today, the design engineer goes into conference not only on the *why* and the *what* but on the *how* involved in the problem before him. He discusses with others not only the need for the device to be designed, the exact degree of product-performance expected, but also the means *already at hand* for constructing the new apparatus.

IN ASSURING the successful operation of his product by the use of instruments and devices for exact measurement, critical inspection, scientific testing and automatic control, he works in cooperation with the engineers who must build his design and the sales engineers who must sell it. Together they determine what is expected of the product, and because of the fact that most things designed now represent an urgent need, they review units available to make such performance dependable.

MODERN MECHANICAL equipment is more often than not the product of many men's brains. Countless times it is designed to fit into processes already functioning. Its primary purpose is one of co-ordinated usefulness.

SPECIALIZED INSTRUMENTS will continue to be of increasing importance. As important as they have been in the past, and are proving to be today, their role in the future will be magnified in the ever growing intricacy of engineering concepts and accomplishments.

Instruments

THE MAGAZINE OF MEASUREMENT AND CONTROL

THE INSTRUMENTS PUBLISHING COMPANY • 1117 WOLFENDALE STREET • PITTSBURGH, PA.

This advertisement was prepared for INSTRUMENTS *by Hardy Advertising, Chicago, advertising agency for Sola Electric Company, Chicago, manufacturers of* SOLA CONSTANT VOLTAGE TRANSFORMERS.

position DIRECT), or with connection to amplifier or oscillograph directly. The POWER has *not to be turned on* and synchronization as well as degree marker will work provided all corresponding connections are made.

The instrument has been in use for over three years and gave very satisfactory service under rather severe circumstances.

TESTING PROCEDURES

Continued from page 541

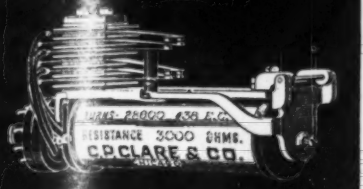
thing wrong in their operations, usually after the quantity or quality of their product has been affected. As an example of post-mortem testing, take the producing a munitions component. *After* a certain percentage of its product has been rejected by a government agency, this company starts testing furnace atmospheres, checking temperatures and time of heating, analyzing materials, etc., in an attempt to locate and correct adverse factors. The fallacy of such a procedure lies in the fact that there is no guarantee that the faults which had caused the trouble will still be present when the post-mortem or trouble-shooting investigations are being made. (Frequently, individual employes will see to it that they are corrected at the start of the investigation.)

Then we have the observation method of testing operations—or the "record-and-control" system of testing—in which technical abilities are used to obtain continuous and complete records of rates, quantities and efficiencies—these records being used to catch and quickly correct any mistakes and to detect gradual deviations from normal. This record-and-control type of operation testing may be illustrated by a large electrical generating company which makes continuous hour-by-hour efficiency tests of its boilers, dynamos, interchangers, etc.,—or a gas company making a continuous hour-by-hour test record of quantities and qualities of materials used and produced and of conditions in its production and purifying equipment. Any deviations from normal productivity and efficiency are readily apparent, and, from the accompanying records of rates and conditions, the cause usually can be speedily detected and corrected.

The ultimate in the application of testing work to operations is "directive" testing—in which the results of preliminary or anticipatory tests are used to direct and regulate ensuing operations. As an example of directive testing, a local paint company can be mentioned. The conditions and operations in each of the nine or ten steps in the manufacture of this company's product are predetermined and prescribed by the results of tests made during and at the end of the *preceding* step. Preliminary tests results determine and control all of the operations of the plant.

We may compare these various degrees of application of testing to operations, by means of a simile:

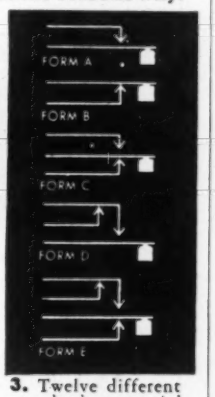
This CLARE Relay Can Take the Place of Many



Clare Type C d. c. Relay

■This rugged multiple-contact relay permits innumerable contact arrangements. Permits designing to small size, with a lesser number of relays; and facilitates maintenance. Adapted for use in electronic control devices and for sequence control and interlocking operations. Ideal where unusual arrangements of relay control are desired. Here are the reasons why:

1. Contact springs employing any of the forms illustrated can be furnished.



2. Spring pile-up insulators of heat treated Bakelite which permit punching without cracks, have minimum cold flow and low moisture absorption content. Assembly locked together under hydraulic pressure. Withstands heavy breakdown tests.

3. Twelve different standard or special types and sizes of contacts can be furnished. Contacts are overall-welded to nickel silver springs. Sizes range from .062" silver, rated one ampere, 50 watts, to .1875" tungsten, rated four amperes, 500 watts.

4. Spring bushing insulators are Bakelite rod made by a patent process. Strong, hard, long wearing. Essential where heavy contact pressures are employed, where vibration exists, or heavy duty service is desired.

5. Armature assembly single or double arm. Has stainless steel shaft, operating in a marine brass yoke. Heel piece, coil core and armature are magnetic metal carefully annealed. Designed for d.c. service.

6. As illustrated, relay has octal base plug mounting for easy service and replacement. Other mountings, and Bakelite or metal cover, can be supplied.

• • •

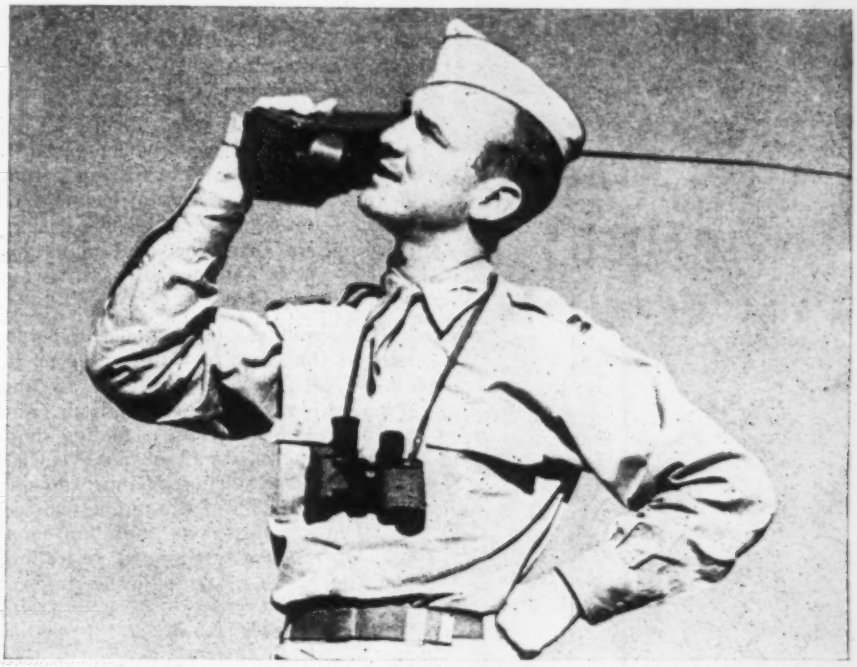
This relay is an example of Clare "custom-built" design and construction. Clare engineers can "custom build" a relay to meet your specific requirements—one that will reduce your overall relay cost and simplify your design problem. Write for catalog and data book. C. P. Clare and Co., 4719 West Sunnyside Avenue, Chicago.

CLARE RELAYS

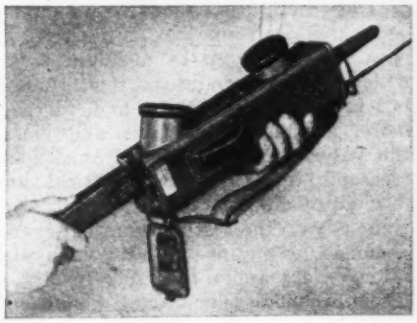
"CUSTOM-BUILT" Multiple Contact Relays for Electrical, Electronic and Industrial Use

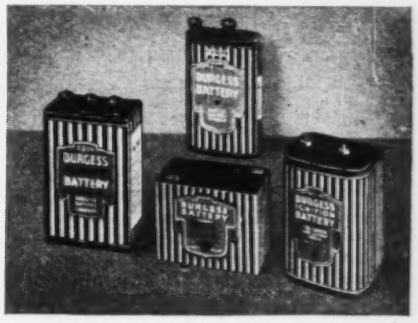
PORTABLE POWER PROBLEMS

THIS MONTH—SIGNAL CORPS' "HANDIE-TALKIE"



A POWERFUL HANDFUL, capable of calling tanks and planes for support or attack, the "Handie-Talkie" is the electronic answer to modern warfare's demand for a light, compact communication unit. Lightweight Burgess Batteries give the "Handie-Talkie" necessary energy to operate under all conditions and in any climate.





SPECIAL-PURPOSE BATTERIES. The battery needed to operate the "Handie-Talkie" was developed by Burgess engineering research to give dependable service wherever the Army goes. Burgess engineers are constantly creating new special-purpose batteries, and new uses for standard batteries. Let them solve *your* portable power problems. Write about your specific needs, or *send coupon below for free Engineering Manual.*

FREE . . . 80-PAGE ENGINEERING MANUAL!

25 charts and 36 data tables on characteristics of dry batteries for electronic applications. Also 31 descriptive pages. Tabbed for ready reference. Write Dept. 4 for *free* copy. *Burgess Battery Company, Freeport, Illinois.*

Name .....

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City ..... *State* .....

BURGESS BATTERIES

LUXTRON* PHOTOCELLS

Offer Circuit Simplicity and Long Life

PLUG-IN CONTACT is only one of a series of mounting types available in all shapes and sizes.

The ability of Luxtron* Photocells to operate instruments and instrument relays, without amplification, removes the hazards of complex circuits. This fact alone recommends their application to precision control problems. Using Luxtron* cells also makes for lighter and less bulky equipment.

Their exceptional resistance to vibration, shock and general mechanical violence assures long service and unusual adherence to original calibration.

Engineering inquiries always welcome.
Full data sent on request.
*Reg. U. S. Pat. Off.

BRADLEY LABORATORIES, INC.
82 Meadow Street, New Haven 10, Conn

The company using "post-mortem" testing of its operations is like the man who doesn't go to a doctor until his health is so bad he can't work efficiently;

The company using "record-and-control" testing is like the man who submits to a periodical medical examination so as to be able to apply corrective measures as soon as his heart starts to murmur;

The company using "directive" or preparatory testing can be compared to the man who doesn't wait for actual sickness, or even threats of sickness, to appear—but who regulates his eating, sleeping, and drinking, and plans his efforts and relaxations so as to avoid sickness or injury.

This simile can be extended by pointing out that, just as "preventive medicine," with its improved diets and periodical medical examinations and regular planned living, is finding more widespread acceptance in our everyday lives, and is resulting in improvements in general health of the public—so too, continuous observation and "anticipatory" methods of testing and controlling operations are gradually replacing the old post-mortem use of testing facilities. One major factor in the change from intermittent post-mortem testing to continuous and directive testing of operations is the improvement of combinations of instruments and control devices. The old-style Bourdon-tube gage which merely *indicated* pressure, so that if a man looked at it he could go over and close one valve a quarter turn and open another two turns, is now being replaced by a single device which not only indicates the pressure but records it on a chart and, furthermore, automatically opens and closes the valves. There are electronic, spectroscopic, polariscopic, analytical and mechanical devices which not only continuously do the testing work of several chemists or engineers, but which also immediately apply the tests results to alter or modify operating conditions. (If you don't believe it, just talk to an instrument company salesman! He'll tell you that all that's needed now to run a plant is a bunch of instrumented controls and a boss to take inventories!)

TESTING OF EQUIPMENT

To the extent that testing and control of operations in a company becomes more definitely combined and mechanized, that third field of testing, which is related to the maintenance and adjustment of control equipment and instruments, becomes more important. In this latter field of instrument testing and maintenance, one point may be stressed: all testing, calibration, and adjusting of measuring instruments and automatic controls should be performed in accordance with fixed schedules, and the results should be fully recorded. Equipment should be tested at definite intervals, depending on the

(Continued on page 586)

COPROX RECTIFIERS

Offer Leads at any Angle to Mounting Lugs

"COPROX" MODEL CX-2E2D4, double half-wave rectifier rated up to 4.5 volts A.C., 3.0 volts D.C., 2.5. milliamperes D.C.

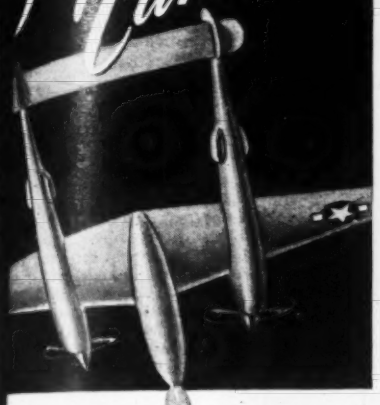
Great latitude in mounting "Coprox" (copper oxide) rectifiers is afforded by the unique mounting lug and the fact that leads may be ordered at any required angle to the lug.

Lead wires are pre-soldered, to prevent overheating in assembly. Gold-coated "pellets" retard aging. Low forward resistance, high leakage resistance. Conservative ratings and high testing standards.

Write for full technical data on all "Coprox" models.

BRADLEY LABORATORIES, INC.
82 Meadow Street, New Haven 10, Conn

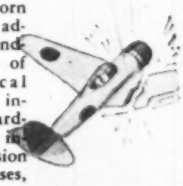
EYES for the *Flying Cannon*

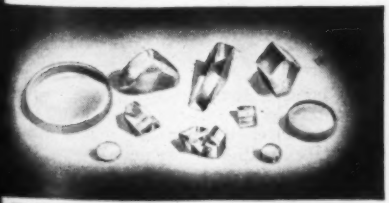


● Grim, deadly fighters . . . the flying artillery of the skies that flash with incredible speed to search out the enemy and destroy him—in the air, on the ground, on the sea—have first call on today's production of precision optics at Univis. But, tomorrow the same craftsmen and precision craftsmanship devoted exclusively to producing these precision lenses, mirrors and prisms for War, will be turned to the manufacture of precision optics for peacetime needs.

PRECISION IS A HABIT WITH UNIVIS

. . . a priceless habit born of years of faithful adherence to precision standards in the manufacture of finest quality multifocal ophthalmic lenses. We invite correspondence regarding your post-war plans involving the use of precision instrument mirrors, lenses, and prisms.





UNIVIS

INSTRUMENT LENS DIVISION
THE UNIVIS LENS COMPANY
DAYTON 1, OHIO

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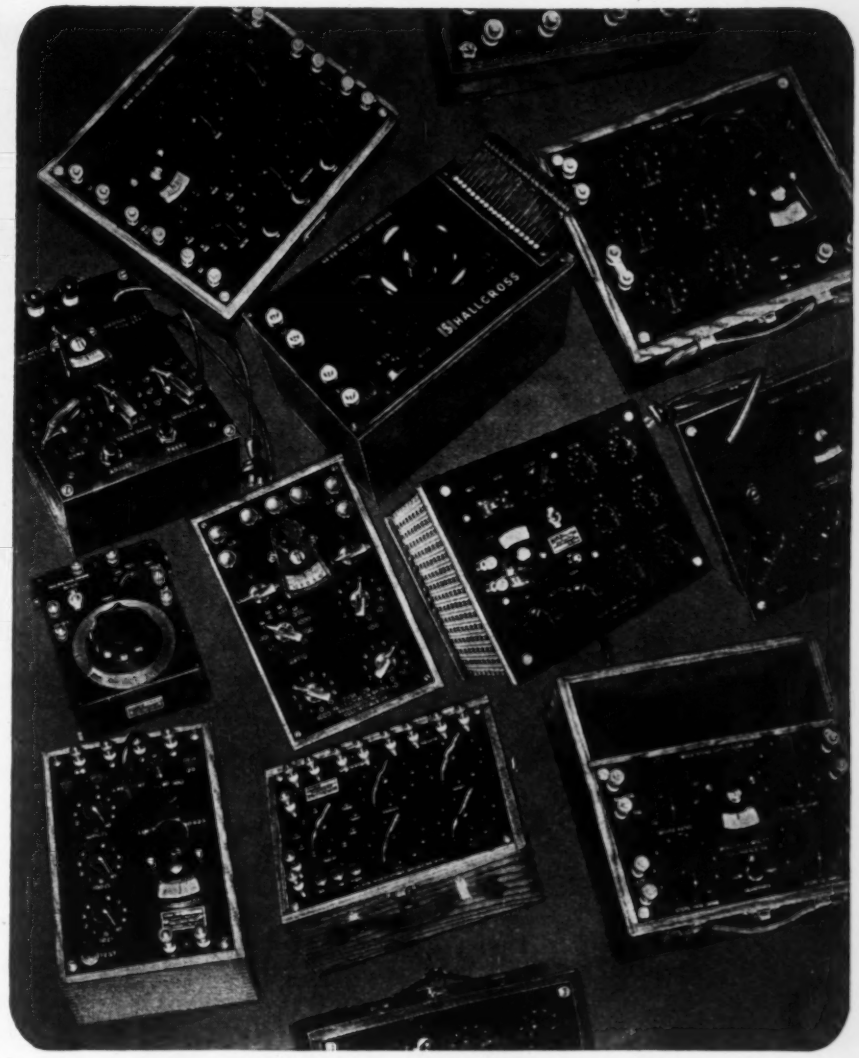


Shallcross INSTRUMENTS for ELECTRICAL MEASUREMENTS

Ayrton Universal Shunts
Standard-, Secondary-, and Multi-Resistance Standards
Decade Potentiometers
Decade Resistance Boxes
Megohmmeters
Percent Limit Bridges
Wheatstone Bridges
Kelvin-Wheatstone Bridges
Low-Resistance Test Sets
High-Voltage Measuring Apparatus
Special Telephone and Telegraph Instruments
. . . and many others

Whether for laboratory, school, production, or maintenance use, Shallcross offers an extensive line of electrical measuring apparatus, fully tested and proved through years of use under all conditions and in all parts of the world.

WRITE FOR CATALOG—or describe your requirements and our engineers will gladly make specific recommendations.

SHALLCROSS MFG. CO.

ENGINEERING • DESIGNING • MANUFACTURING

Dept. IS-94 •Collingdale, Pa.

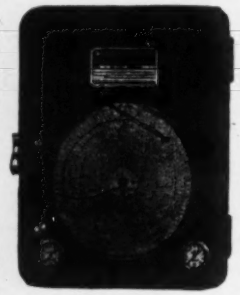
CONTROL SYSTEM

The Mark of

Effective Control

Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

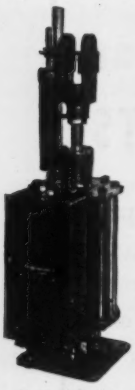
Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.



Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

C-3

BAILEY METER COMPANY

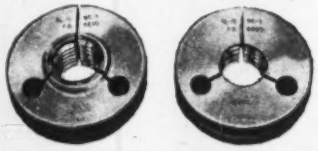
1041 Ivanhoe Rd., Cleveland, Ohio

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Ring Gages for External Threads

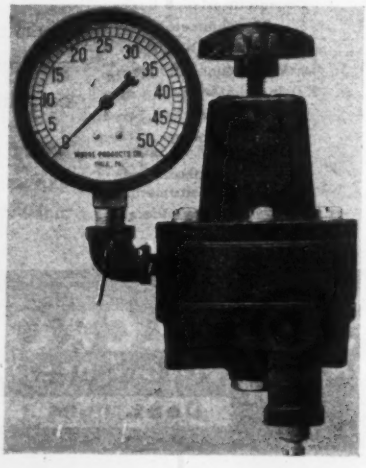
New ring gages are said to incorporate all features desired by inspectors for gaging external threads. They are made from tool steel, heat-treated to Rockwell hardness of



63 to 66. Gaging surfaces are lapped. Gages may be returned to maker for inspection and reset to the master gage. If worn, they will be reconditioned, set and sealed. For users' convenience, maker maintains setting plugs of standard pitch diameter in the following classes: National Coarse 2 and 3, National Fine 2 and 3 and National Extra Fine class 3, in sizes up to 1½". Size 10 and larger ring-gages have first thread completely removed to prevent chipping, facilitate use and add to life of gage. These new ring gages are made in sizes from No. 6 to 12" diam. They are ground in National Fine, National Coarse, National Extra Fine, Metric, Whitworth and in other standard thread forms. Special pitches and special thread forms in right- or left-hand threads can be secured on special order. As illustrated, new ring gages are clearly marked "G" or "No Go." In addition, "No Go" ring gages have a mid-ring cut in knurled edge. All Vard ring gages, unless on special order or special blueprint design, are made to American Gage Design Standards and are adjustable. —*Vard Inc., 2961 E. Colorado Blvd., Pasadena 8, Calif.*

Pressure Regulator

New "Nullmatic" pressure regulator is designed to hold air pressure constant, regardless of changes in flow as well as variations in supply pressure. Further claim is that constant regulated values over long periods of time are also functionally inherent in new design. Regulator operates on



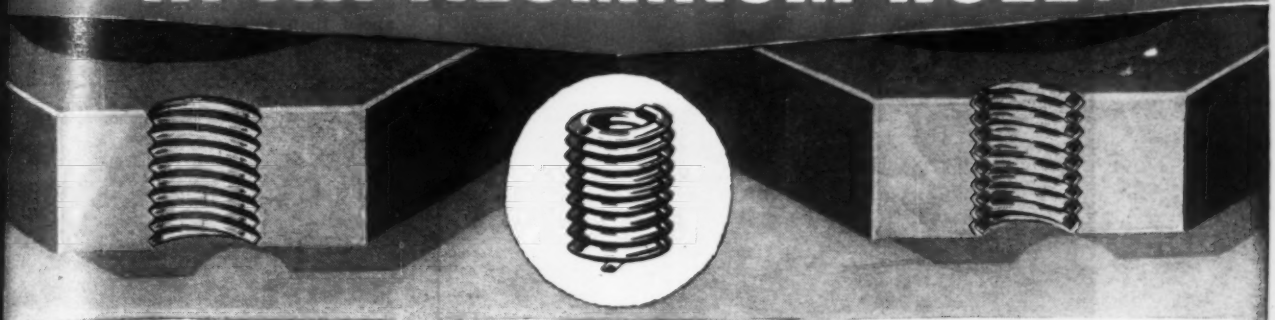
the pneumatic null balance principle [illegible] may better be described as a pressure [illegible] troller, since main air valve is operated [illegible] a detecting nozzle. This nozzle operates [illegible] a constant differential pressure to hold [illegible] ual loading spring at essentially the [illegible] position, regardless of variations in [illegible] or in supply pressure. An automatic bl[illegible] operates when a reduced regulated press[illegible] is required; also serves to permit reve[illegible] flow when regulator is used as a limit c[illegible] trol on industrial instrument applicatio[illegible] A separate safety release operates a [illegible] pounds above the regulated value. All [illegible] terials in contact with the air are corrosi[illegible] resistant. Neoprene diaphragms used [illegible] suitable for continuous operation at te[illegible] peratures up to 225°F. A manual adjusti[illegible] knob and a fine thread facilitate accura[illegible] setting. Ease of operation is obtained throu[illegible] a ball thrust bearing. New regulators [illegible] available in three standard ranges: 0-[illegible] 0-30 and 10-50 lbs./in.² and are suitable [illegible] use on supply pressures up to 150 lbs./in[illegible] Provision is made for panel or pipe mou[illegible] ing as required. With 100-lb. supply pr[illegible] sure and a 25-lb. regulated pressure, ma[illegible] mum capacity is approximately 10 s.c.f.m. *Moore Products Co., H and Lycoming Sts., Philadelphia 24, Penna.*

Electronic Relay

New electronic relay amplifies minu[illegible] current transmitted by delicate control co[illegible] tacts or high-resistance circuits, thus m[illegible] terially increasing the application range

many control devices. Operated by any m[illegible] terial having a resistance of 0 to 500,0[illegible] ohms (greater if necessary) new relay [illegible] especially suitable for controlling liqu[illegible] levels in tanks and boilers, sorting metall[illegible] parts by size, detecting broken threads [illegible] textile machines, and as a limit switc[illegible] requiring extremely light pressure to op[illegible] erate. It consists of a standard type electro[illegible] tube, a supply transformer, and an elec[illegible] tromagnetic relay—all mounted in totall[illegible] enclosed, weather-resistant enclosure suit[illegible] able for wall or machine mounting. In op[illegible] eration, electromagnetic relay in device [illegible] kept energized as long as controls connecte[illegible] to input grid circuit of electron tub[illegible] remain open. When these contacts close, th[illegible] relay [illegible] de-energized. A built-in time delay featur[illegible] prevents chattering when contacts in inpu[illegible]

HOW TO PUT A *Steel Thread* IN AN ALUMINUM HOLE!



This unprotected tapped thread in Aluminum will wear rapidly may even strip **BUT**

Take this precision-shaped stainless steel "Heli-Coil" Screw Thread Insert **AND**

Insert it in the tapped hole. Now you have, in effect, put a long-wearing steel thread in an aluminum hole.

"Heli-Coil" Screw Thread Inserts provide a simple and inexpensive method of protecting tapped threads in light metals and plastics against abrasion, stripping and seizing. Furnished in stainless steel or phosphor bronze, they can be installed quickly with hand or power tools. Manufacturers of aircraft engines and accessories use "Heli-Coil" Inserts in applications where solid screw bushings were used previously. In fact, almost the entire output of this Company is used for aviation purposes today. These inserts are used not only in original construction, but in salvage, replacement and maintenance—in the factory and in the field. The fact that they meet the rigid requirements of aircraft engine manufacturers indicates wide usefulness throughout industry after the war. Send for engineering literature.

USED IN ARMY, NAVY AND TRANSPORT AIRCRAFT ENGINES, ACCESSORIES AND PARTS FOR SALVAGE • MAINTENANCE FIELD SERVICING AND ORIGINAL INSTALLATION

Heli-Coil INSERTS SAVE

TIME

Can be installed with simple hand or power tools in one-fourth the time required for solid screw bushings.

WEIGHT

Weighs one-fifth as much as the screw bushing of the same diameter.

SPACE

Occupies less than half as much cross sectional area as solid bushing, permitting more latitude in design.

METAL

Made from precision-shaped wire with no waste, requires about one-tenth as much metal as solid bushing made from bar stock.

THE SCREW SYSTEM WITH THE ANTI-FRICTION THREAD LINING

U. S. and Foreign Patents Issued and Pending

AIRCRAFT SCREW PRODUCTS COMPANY, INC.

47-23 35th STREET • LONG ISLAND CITY, 1, N.Y.

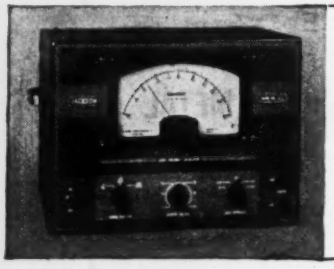
Doing an Outstanding Job

Jackson Service Labs provide custom-built appearance, but are comprised entirely of standard Jackson instruments—providing testing facilities to suit individual requirements.

New ones aren't available now, of course, but will be again—some day. But many of them are still performing—easing the work of service men everywhere, and contributing to the greater satisfaction of radio listeners.

The dependable performance of these pre-war Jackson instruments is more than matched by the stamina and accuracy of today's war-time models. Either or both, they demonstrate the INTEGRITY OF DESIGN that you'll want in your post-war instruments—by Jackson!

Buy War Bonds and Stamps Today



New Jackson Instruments, improved through war-time design and tested by war-time use, will be available to cope with the tremendous post-war radio rush. In the meantime, maintenance of Jackson instruments is an obligation that we honor as promptly as possible under war-time conditions.

Model 652 Audio Oscillator

JACKSON

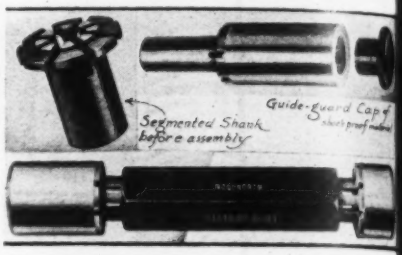
Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

circuit are momentarily closed. A contact arrangement on the electromagnetic relay permits device to be used either to make or break a load circuit when actuating contacts connected to input circuit on electronic relay are closed.—*Industrial Control Division, General Electric Co., Schenectady, N. Y.*

Carboloy Gages with Segmented Shanks

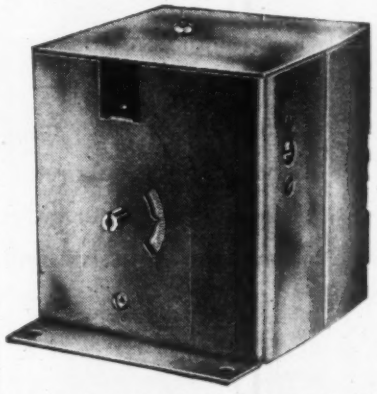
New type Carboloy gage with segmented shank is lighter in weight and better balanced than solid types; is said to assure less operator fatigue and more accurate



inspection than with other types. Permanent bonding of cemented carbide bushings to steel shanks in manufacture of cylindrical plug gages had presented a problem, but segmented shank is said to compensate for different temperature coefficients of expansion of cemented-carbides and steel, is said to assure a trouble-free bond between these two metals. Segments separated by slots permit "breathing" and allow for expansion or contraction resulting from temperature changes, with no distortion of Carboloy gaging member. Carboloy plug gages range in size from 0.059" to 1.510". As a gage material, Carboloy has been found to outwear steel many times—particularly when gaging highly abrasive material. It is highly resistant to corrosion. A guide-guard cap of shock-proof material protects the Carboloy bushing-type gaging member and also serves as a "pilot" for quick location of gage in work. Cap is easily removed, permits the gages to be used for "blind" holes. Hollow bushing plus slots in shank automatically form an air vent.—*N. A. Woodworth Co., Ferndale, Mich.*

Shock-proof Impulse-initiated Timer

New "Type PSEH-1" impulse-initiated timer is 71.8% smaller by volume than previous conventional units used for similar applications, is said to have added advan-

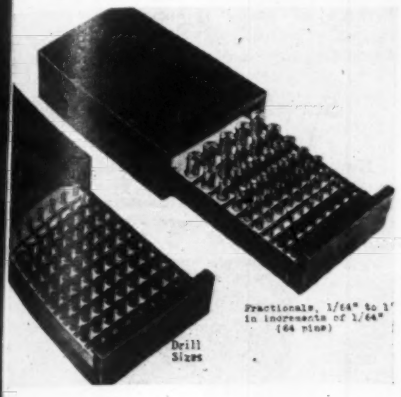


tages of rugged, shock-proof construction, easily-accessible contacts and dust-proof cover. It is made in both a-c, and d-c types. Contact operation occurs at the end of a delay interval after power has been applied, or after receipt of a momentary impulse from a push-button, limit switch, or other source. Adjustable timing range is 20-to-1, and mechanism is immediately recycling. A built-in d-p.d-t. auxiliary relay provides a variety of circuit arrangements common

to, or isolated from, the control circuit. Type PSEH-1 Timers can be supplied for a-c. operation on 110-volt 60-cycles or 25-cycles; 220-volt 60-cycles or 25-cycles; or for d-c. operation at any specified voltage from 6 to 120 volts. Size of a typical unit is 3½" × 3⅝" × 3⅝".—*Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.*

Pin Gage Sets

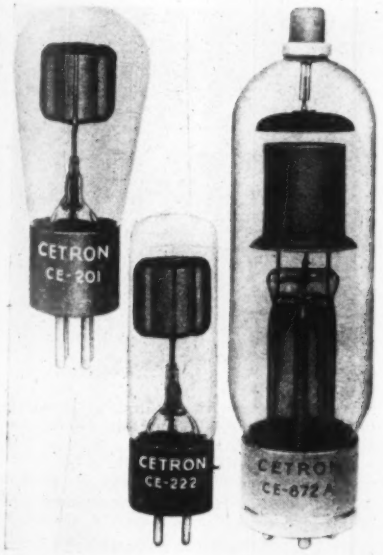
New cabinets completely furnished with precision pin sets, number drill, letter drill and fractional sizes, are announced. Number drill sizes 1 to 60, letter drill sizes A to Z,



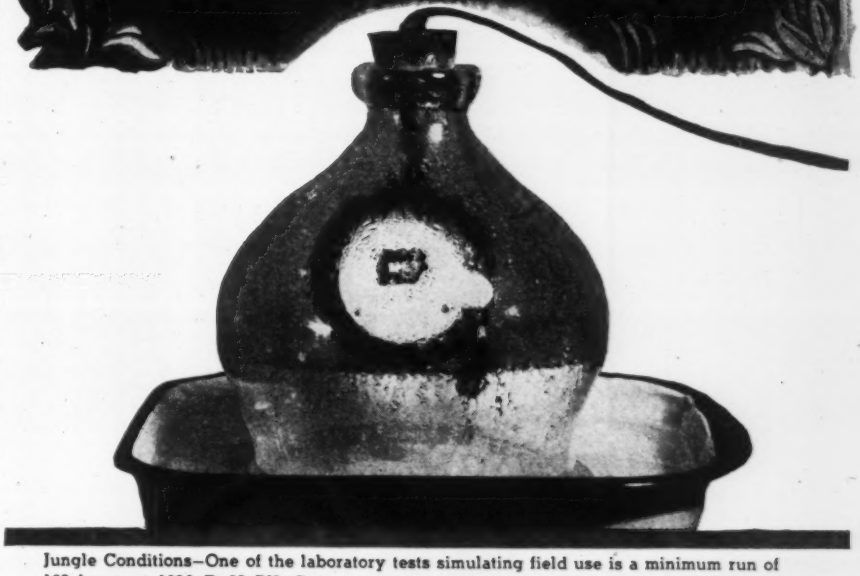
(86 pins) and fractionals 1/64" to 1" in increments of 1/64", (64 pins) are said to be of the finest quality gage steel, hardened to 60-63 Rockwell C Scale and finished to ultimate accuracy by "UPPCO-Lapped method." Tolerances are made to individual specifications. Walnut-finished cabinets are especially designed and fitted for their purpose. Brass strips with letter, number or fractional permanently fixed in white, identify each gage at its position. Gages are progressively stored for instant pick-up. Smaller pins are in glass vials with heavy plastic screw tops, and felt cushions at the bottom for added protection. Gages are protected from moisture, corrosion and dirt. Cabinets are 9⅞" wide, 15½" long and 4½" high.—*United Precision Product Co., 152½ West Belmont Ave., Chicago 18, Ill.*

Rectifier Tubes

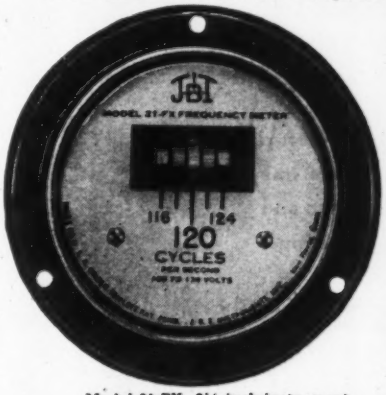
New types (or improved models) of rectifiers for industrial applications are announced: (1 & 2) "CE-200" and "CE-201" mercury-vapor rectifier tubes are said to fill the need for a 2-ampere full-wave rectifier which is suitable for applications up to about 250 volts d.c. These are not new types but have been redesigned for improved performance. Low average arc drop



Jungle-Proof FREQUENCY METERS



Jungle Conditions—One of the laboratory tests simulating field use is a minimum run of 120 hours at 120° F, 95 RH. Component parts have previously been tested at 180° F.



Model 21 FX—2½ inch instrument with plastic case for use where weight and space are important.

IF you had to work in a jungle, the stifling heat and humidity approaching the saturation point might get *You* . . . but *not* J-B-T Frequency Meters. These meters can take it . . . and do . . . heat and moisture notwithstanding.

Suspended in open bottom bell jars over steaming water, J-B-T Frequency Meters consistently indicate correct frequency or speed although dripping wet. This is so because in J-B-T simplified construction, the only moving part is the reed, which *throws off* moisture as it operates, and because all component parts are protected by the most advanced moisture-resistant finishes.

Jungle-proofing is not the only assurance of reliability. J-B-T Vibrating Reed Frequency Meters are also unaffected by mechanical shocks, voltage drop, change in wave form or external magnetic fields.

Send for illustrated bulletin VF-43 including VF 43-1A on 400 cycle meters and VF 43-1B on the new compact 2½ inch meters.

(Manufactured under Triplett Patents and/or Patents Pending)

J-B-T

J-B-T INSTRUMENTS, INC.

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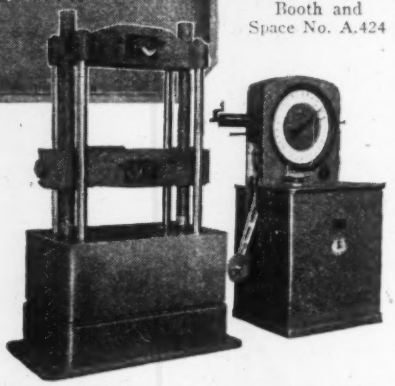


Precision

HYDRAULIC TESTING MACHINES

Pendulum load indication is more accurate and dependable because it operates on the natural laws of gravitation. This principle of operation is not affected by temperature changes or subject to metal fatigue. .

. . . . have repeatedly demonstrated the practical truth in the words, "One Test is Worth a Thousand Expert Opinions." Because they have simplified the science of testing the physical properties of materials they are widely used throughout the wartime industries today. Here Riehle Testing Machines "ferret out" material weaknesses and defects; avoid failures before they occur. This technique of progressive testing on the production line and in research laboratories saves valuable machine and man-hours. Write for descriptive literature and quotations.

RIEHLE *HYDRAULIC TESTING MACHINES*

Riehle Testing Machine Division, American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

Other Products: IMPACT TESTERS • VICKERS HARDNESS MACHINES
BRINELL HARDNESS TESTERS • MEASURING INSTRUMENTS

gives assurance of minimum internal heating, maximum life, and maximum efficiency. Being full-wave, these tubes save equipment manufacturing costs. They are sturdy and of conservative design so that they may be used in the industrial field where momentary occasional overloads may exist. Both tubes have identical electrical characteristics; the difference between them is in the basing. CE-200 has a standard 4-pin base and the CE-201 a special long-pin industrial base, thus making it directly interchangeable with other tubes having the same characteristics. (3) "CE-202" is a long-life high-efficiency rectifier tube designed particularly for the 250 volt d-c. field. It is conservatively designed to operate without blowing at air temperatures encountered in industry. It is conservatively rated at 15 amperes d-c. output and has a 900 volt peak inverse rating which allows its application in most conventional 250 volt d-c. circuits. Low arc drop (7.5 volts) combined with highly efficient shielded cathode design is said to result in an exceptionally high efficiency. It makes use of a patented cathode construction which minimizes damage done when anode voltage is applied before cathode has been allowed to heat to normal operating temperatures. This design makes less essential the use of time-delay relays to prevent application of anode voltage until cathode has heated for required time. This tube is guaranteed for 2,000 hours or 12 months, whichever occurs first. (4) "CE-222" is a new xenon-filled full-wave rectifier tube. It meets all the requirements of RMA 3B22 and is interchangeable with other tubes bearing this number. It is said to have all the advantages of gas-filled tubes, such as quick heating and freedom from the effects of ambient temperature variations. With an average arc drop of 8 volts this tube gives high efficiency as a rectifier. It has a standard 4-pin base and is particularly useful in industrial and other rectifier equipments up to about 200 volts d.c. Its d-c. output current rating is 1 ampere continuous. (5) "CE-872A" mercury vapor high-voltage rectifier tube, originally designed for (and still used to a great extent in) radio transmitters, is now being produced for high-frequency heating equipments. Price of tube is low and value is terms of rectified kilowatts per dollar tube cost is said to be one of highest rating of "CE-872A" is 10,000 volts inverse peak and 1.25 amperes d-c. output. It is said to be produced to standards far exceeding the published rating thus giving the added assurance of many thousand hours life at rating.—*Continental Electric Co., Geneva, Illinois.*

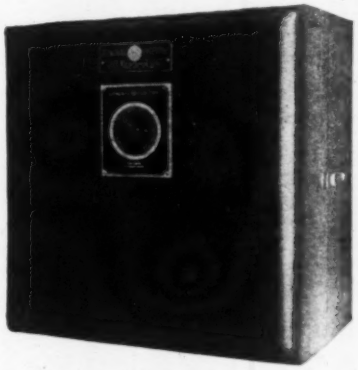
Supplementary Lens for Inspection Magnifiers

New attachment for "Flud-Lite" magnifiers Nos. 701 and 701H is an auxiliary lens, No. 05, which doubles magnifying power of maker's inspection tools equipped

with fluorescent lamps. Use of new auxiliary lens is recommended for close inspec- whenever additional magnification is required. Lens is 2½" in diameter is set in a cup-shaped frame, fits easily under lens frame of magnifier and can be attached or removed in a few seconds' time.—*Stanley Electric Tools, New Britain, Conn.*

Welding Current Controller

New "CR7503-D157" voltage regulator for use with most G-E resistance-welding controls that include the phase-shift method of heat control, is designed to regulate



the welding current automatically, so that this current is held constant regardless of line-voltage variations of as much as +10% or −20%. Quality of weld is said to be greatly improved and continuous readjustment of heat setting is unnecessary. New regulator consists of a resistor circuit connected to power line which supplies welding

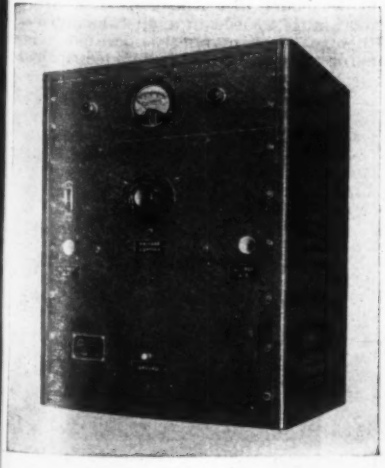
machine, and an electronic circuit. When regulator is in use, this electronic circuit functions not only to hold average voltage of resistor current constant, but also changes, electronically, phase control voltages of main welding control panel. Thus if line voltage drops (which normally would cause current through welding transformer and resistor circuit voltage to vary correspondingly) regulator advances the phase control voltages, thereby automatically holding welding current constant "within close limits." Regulator is housed in easily-opened steel enclosure, can be used on welding circuits whose power factor is from 90% to 70% and can be operated from 230/460/575 volts on a 50/60 cycle power supply. It operates whether or not the welding current is flowing. This feature enables it to compensate for a sudden voltage drop in less than three cycles, with approximately 75% of the compensation taking place during the first cycle.—*Industrial Control Division, General Electric Co., Schenectady, N. Y.*

Thread Data Reference "Slide"

New pocket-size easy-reading thread slide is designed to save time for engineers, draftsmen, inspectors, machinists and students. The device consists of a pocket, and a slide of Bristol board on which are printed all specifications for screw and nut for classes 1, 2, 3 and 4 fine and coarse threads. As slide is moved, a slot in pocket exposes readings for any desired size screw. Tables on the pocket make it easy to obtain readings to fit special thread dimensions and tolerances, and for special screw sizes. Time studies indicate that thread specifications can be obtained with the slide in 1/40th the time required for computing such information from tables in available manuals. All computations on slide are based on National Bureau of Standards' specifications.—*S & B Engineering Co., 507 N. St. Clair Street, Pittsburgh, Pa.*

Voltage-breakdown Tester and Test Fixture

New "Type P-3" Voltage Breakdown Tester is said to provide a simple, positive, safe and quick means of testing voltage breakdown of materials or components. Operating range of instrument is 0 to 10,000 volts d.c., or 0 to 8,000 a.c. A lower range instrument, "Type P-1," with sloping panel, has a range of 0 to 4,000 volts d.c., or 0 to 3,000 volts a.c. Voltage is continuously variable over the entire range. Tester operates directly from 110-130 volt 50/60-cycle ac. line. A panel light indicates when instrument is ON. Breakdown is indicated by a red signal light, while built-in indicator gives a direct reading of voltage. Current-limiting resistors safeguart equipment in event of a dead short, by limiting current to approximately 50 milliamperes. Uniformity over entire range on "Model P-3," or 5 milliamperes on "Model P-1." To speed



The "FRAHM" VIBRATING-REED HAND TACHOMETER . . .

requires no contact with the rotating element and is unique for measuring speed of totally enclosed machines and other equipment where the end of the shaft is not accessible. The only mechanism is a set of accurately tuned steel reeds which vibrate by resonance according to the speed of the machine with which the instrument is held in contact.

For hand use in servicing, installation and maintenance work; also built in types for permanent mounting. Various ranges available from 900 to 30,000 r.p.m.

Write for descriptive Bulletin 1590-I.

The JONES HEAVY DUTY HAND TACHOMETER

is used for indicating r.p.m. and surface speeds of all types of machinery in which the moving parts are readily accessible. Simple, rugged and reliable, it is built to maintain accuracy in hard, everyday service. Single and triple range models up to 12,000 r.p.m. supplied complete with carrying case and accessories.

Write for descriptive Bulletin 1710-I.

. . . The JAEGER SPEED INDICATOR

is a "vest-pocket" speed-measuring device which adds up the number of revolutions over a period of six seconds and shows the revolutions per minute without any calculations. Can also be used to measure speeds in feet per minute. Available in two models—for all speeds up to 2000 r.p.m. and for all speeds up to 10,000 r.p.m. Supplied complete with carrying case and accessories.

Write for descriptive Bulletin 1750-I.

JAMES G. BIDDLE CO. **1211-13 ARCH STREET PHILADELPHIA 7, PA.**

Amazing New Four Spindle Turret Attachment for Drill Press!

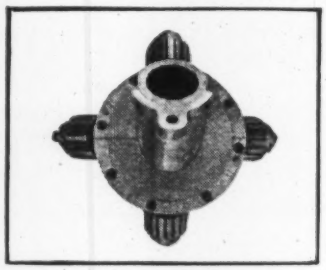
Now one drill press can do the work of four and, at the same time, effect a savings of up to 75% in floor space, with the "Quadrill" attachment. This rotary device will accommodate four boring or cutting tools at the same time, yet one tool *only* is in motion when the head is in operating position.

The entire unit is assembled to the quill of the drill press and is driven from the drill press spindle. Accuracy and rigidity of alignment of the "Quadrill" are assured by the special construction of the driver and spindles, thus efficiency is only limited by the accuracy and power of the drill press itself.

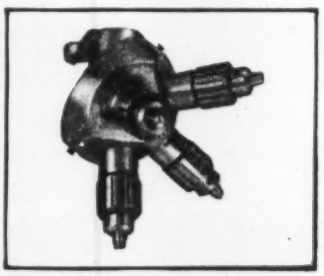
Foolproofing in indexing is accomplished by visual markings and by the relationship of the index pointers on the index disc, as well as the extension of the spring retainer. Four hardened and ground spindles are fitted for No. 32 Jacobs chucks or their equivalent. To provide correct positioning at all times, the entire spindle assembly is located by means of an accurate fitting of recess and undercut, between turret and bearing housings. The hardened friction starter and driver have been so constructed that at any speed proper synchronization of the driver teeth is accomplished without clashing.

It goes without saying that our fighting men must have the finest possible quality materials home industry can produce. So, although the stock of quality raw materials from which Wrigley's Spearmint chewing gum is made is growing steadily smaller, they are still maintaining pre-war standards. However, they can now make only a portion of their former output, so all of this limited production is going to our fighting men and women overseas only . . . where it is an "on-duty" need.

You can get complete information from Chicago Drillet Corporation, 919 N. Michigan Ave., Chicago 11, Ill.



Quick and positive indexing assured by pointers on index disc



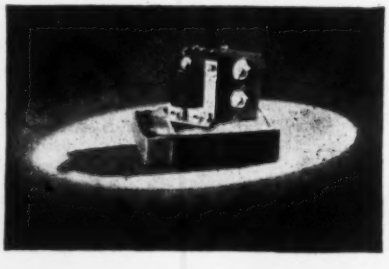
Quadrill assembly complete ready for attachment to drill press

Y-140

up production testing. *Drawer-switch Type Fixtures* are available: these have a jig to take given components or materials, and voltage is applied when drawer is closed, with absolute safety for operator. External connections are made by means of an insulated plug inserted in the high-potential a-c. or d-c. jack, with the other side grounded. Tester is housed in a fine-grained crackled-enamel metal cabinet measuring 15″ × 21″ × 28″ high.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

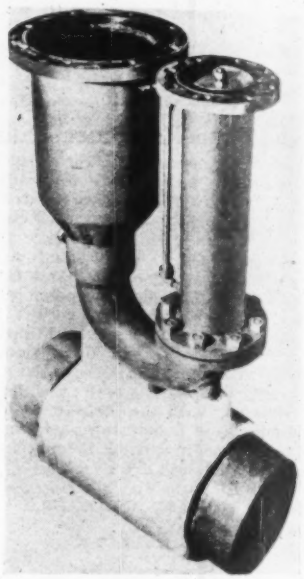
Autotransformers for Aircraft

Two small size autotransformers, especially designed to furnish proper a-c. voltage for operation of 400-cycle aircraft instruments such as the remote indicating compass, are light in weight, the 6 volt-ampere unit weighing 2 oz. and the 12 va. unit weighing 3 oz. Dimensions are approx. 1¾″ × 1¼″ ×1$\frac{1}{16}$″. Both units operate over a frequency range from 380 to 420 cycles. They can be applied on planes that have a 110/120-volt a-c. power source available, obviating need for additional inverters. Their use allows more complete utilization of the available a-c. power source. With sufficient ventilation, new autotransformers will operate efficiently at any altitude. Core and coil units are impregnated with moisture- and heat-resistant Glyptal clear varnish. All exposed solder joints are coated with G-E Red Glyptal to prevent corrosion. Mounting clamps and terminals are also suitably protected against corrosion. While rated at 120 volts input, they are suitable for operation over a voltage range from 110 to 130 volts.—*Special Transformer Division, General Electric Co., Schenectady, N. Y.*



High-vacuum Diffusion Pump

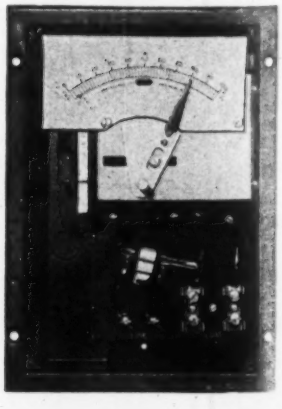
New "Type B-8-O" industrial high-vacuum diffusion pump is said to have remarkable speed pumping characteristics especially when used in conjunction with



the fast-pumping National Research diffusion pump oil. Against a modest foreline pressure requirement of approx. 500 microns Hg abs., it will handle around 2,500 ft.³/min. of free air in the pressure range of 0.1 to 0.01 microns. Made entirely of metal and designed to withstand rigors of industrial use, it has four stages of jets to give high pumping speed and an 8″ inlet flange for large gas-handling capacity. It is equipped with an electric-heated boiler with automatic thermoswitch and has built-in cut-out switches in case water supply fails or boiler overheats. Water cooling coils on the boiler give a short cooling-down period and allow for rapid exposure of pump to atmospheric pressure after use.—*National Research Corporation, 100 Brookline Ave., Boston 15, Mass.*

New Model of "Rheotrol"

New model of "Rheotrol" has been refined and is housed in a flush-mounted case. "Rheotrol" is a manually-operated controller for regulating input to electrically op-



rated furnaces, ovens, heaters, kilns, etc. It is claimed to provide stepless, wasteless control of current supply. It replaces the standard rheostat and, by eliminating the current waste through resistors, provides improved operating efficiency. It is said to place any temperature in the equipment's range at the command of the operator.—*Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.*

Miniature Diffusion Pump

New "VMF" metal pump for producing high vacua (10-6 mm. Hg) is small, compact and of construction radically different from that of previous pumps. It has been designed especially for new-style rotary exhaust machines in which a diffusion pump

moves around with each tube, as well as for portable electron microscopes and similar apparatus. It utilizes fractionating principle discovered by Maker's scientists and does not require any liquid-air trap. Three sizes are available: smallest, "Type VMF-6," 2¾" diam. and 6" high; largest, "Type VMF-20," 5¼" diam. and 9½" high. Intermediate size, "Type VMF-10," has the following characteristics: Speed, 10 liters/sec. at 10-4 mm. Hg; Ultimate vacuum, 10-6 mm. Hg with Octoil-S; Required forepressure, 0.125 mm Hg; Heater power, 135 watts; Height, 7¾"; Width, 3⅞"; Weight, 2.5 lb. Heat transfer problems which had hitherto made small metal pumps impracticable are said to have been solved by a unique boiler design. Units are normally cooled by water, but special air-cooled models are also available.—*Distillation Products, Inc., 755 Ridge Road West, Rochester, N. Y.*

Fungus-proof Resistors and Switches

Announcement is made that Shallcross Akra-Ohm fixed wire wound resistors, Shallcross switches, etc., are now available treated with anti-fungus materials which meet Signal Corps Specifications No. 71-2202A. These units are supplied without any manufacturing delay occasioned by the special treatment.—*Shallcross Mfg. Co., Collingdale, Pa.*

Terminal Block

New "Curtis Feed-thru Terminal Block" for sub-panel assembly is available in sizes up to 16 terminals. It is said to provide a new convenience and wiring simplicity for sub-panel mounting. It consists of individual feed-through terminals, molded in Bakelite, permanently held in a metal strip in any combination desired. Blocks can be supplied with any number of terminals needed. Ter-

CONANT'S *Mighty Midget 160c*

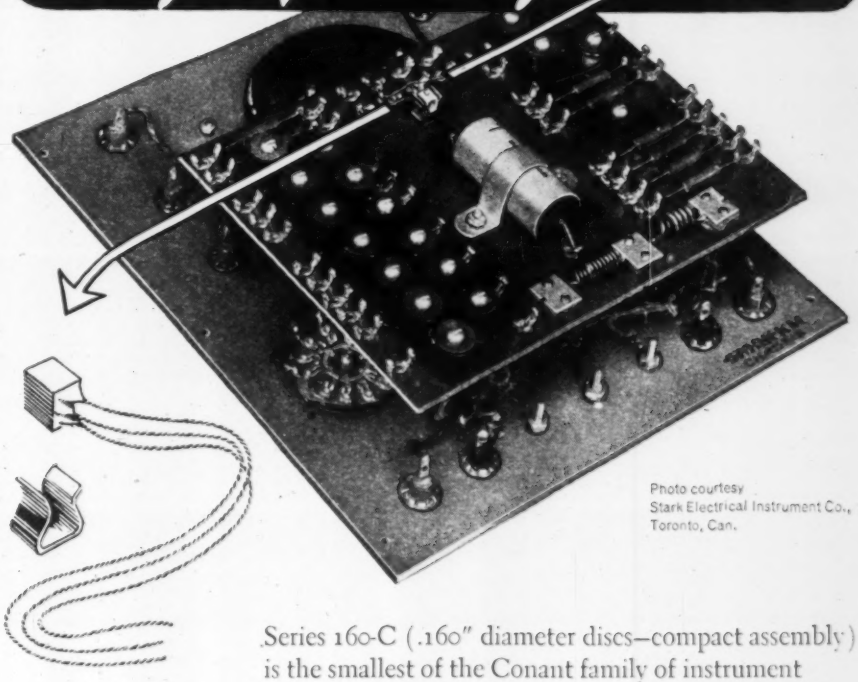


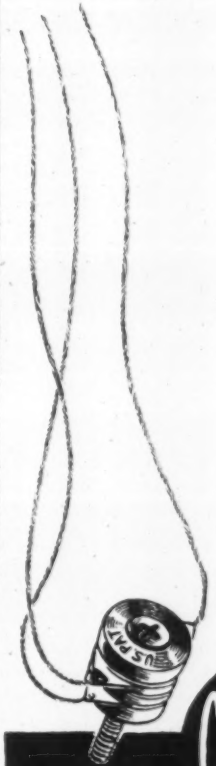
Photo courtesy
Stark Electrical Instrument Co.,
Toronto, Can.

Series 160-C (.160" diameter discs—compact assembly) is the smallest of the Conant family of instrument rectifiers. To attain the utmost in compactness these rectifiers have been stripped of all non-essential material. Not even a mounting bracket remains. (Weight—from 1.293 to 1.743 grams.) They are easily mounted, however, as illustrated above. Here the rectifier fits neatly into a midget fuse clip.

Such mounting permits the rectifier leads to extend in any direction by combining any of three positions of the rectifier in the clip with angular mounting of the clip. This greatly simplifies the job of assembly or replacement.

Complete protection from damage is provided for the rectifier assembly by the full metal case and a special moisture-proof seal.

Wherever the saving of space and weight is important, for all applications embracing high sensitivity and higher frequencies, choose Conant's Mighty Midget, Series 160-C.



CONANT *Instrument Rectifiers*

ELECTRICAL LABORATORIES

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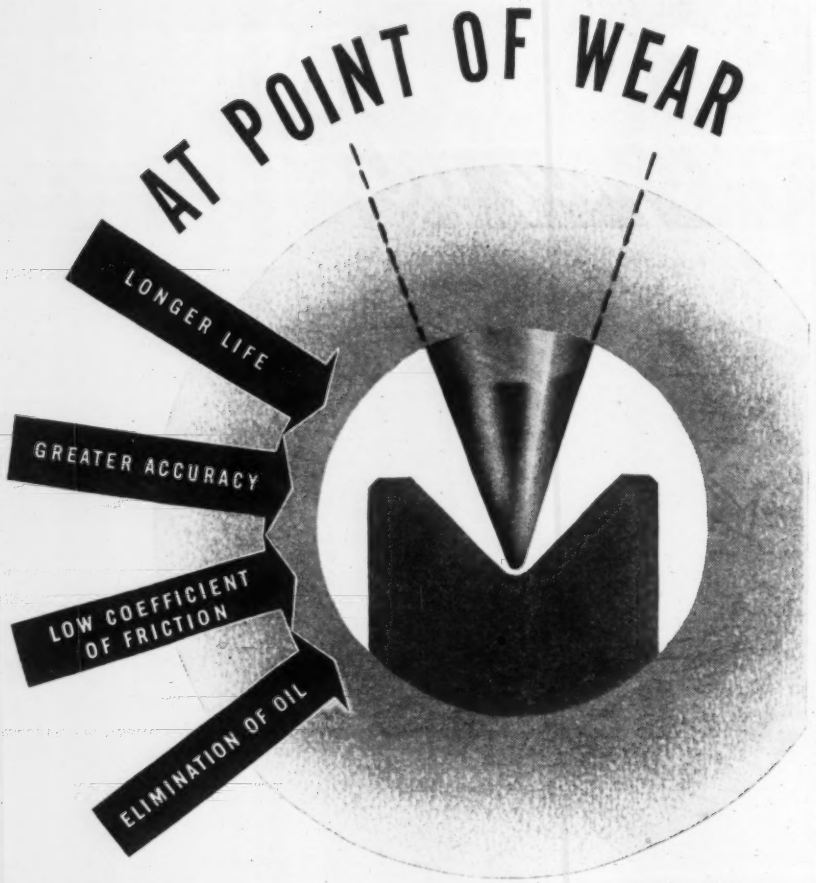
4205 N.E. 22nd Ave., Portland 11, Ore.
Caixa Postal 930, Sao Paulo, Brazil
50 Yarmouth Rd., Toronto, Canada



PERMOPIVOTS

PERMOPIVOTS* are precision made pivots tipped with Permometal* . . . a special precious metals alloy. Permometal is ideally suited for this purpose. Its resistance to wear gives the pivot extra long life and helps to keep the most delicate of instruments accurate longer, even under conditions of extreme vibration. Permometal's extremely low coefficient of friction eliminates oil and contributes much to instrument accuracy. Permopivots are non-magnetic and corrosion proof. Their high performance has made them the preferred pivot of many nationally known instrument makers...and demanded by instrument buyers.

*T. M. Reg.

PERMO *Incorporated*

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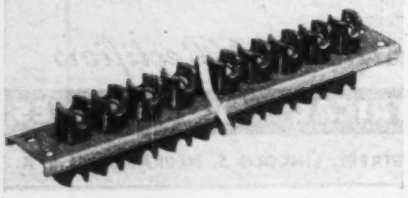
Write today for complete information

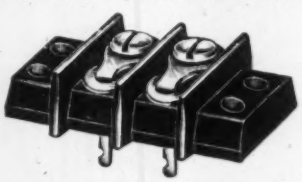
minals have ample clearances and leakage distances for circuits carrying up to 300 volts, 20 amperes. Center-to-center distance is 5/8". No. 8 screws are used on each side of terminal units for securing connection.



The two mounting holes at each end of the terminal base take No. 8 machine screws.—*Curtis Development & Mfg. Co., 1 North Crawford Ave., Chicago, Ill.*

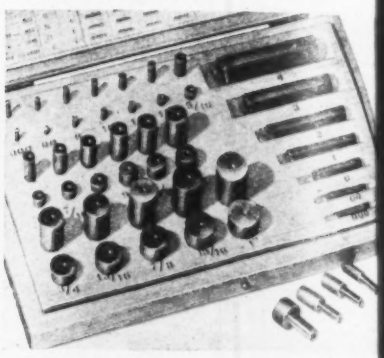
Terminal Strip

New "Type Y" barrier type terminal strip has facilities for connections both above and below the mounting surface, permits a screw connection above panel and a solder connection below, as illustrated. It mounts securely in block and is also held by the screw so that connecting wire comes in direct contact with terminal. "Y" Terminal is made for the No. 140, No. 141 and No. 142 Series barrier strips. Bakelite body is of BM 120 Compound according to Navy Specifications 17P4 and "Y" Terminal is tin plated brass. Barriers separating terminals are of sufficient height to give desired creepage distance and prevent shorts from frayed wires.—*Howard B. Jones Co., 2[illegible] W. George St., Chicago 18, Illinois.*



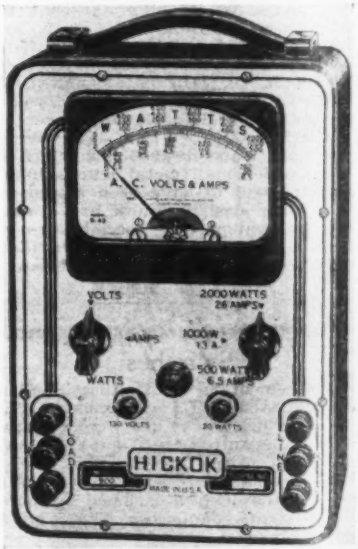
Emergency Plug Gage Blank Set

New "Atlantic Emergency Set" contains 36 cylindrical plug gage blanks in steps of 1/16" with handles as illustrated, will permit any shop to produce any size plug gage from 0.029" to 1.000" in "a few minutes" work on a cylindrical grinding machine. These new gage blanks are oil-hardened and shank finish ground; centers on both ends are lapped. Blanks need only be ground to produce a commercial finish gage where closer tolerances are involved, gages are then lapped. It is said that plug gage manufacturers as well as users can benefit by enjoying savings made possible by the designed company's mass-production methods.—*George Scherr Co., 200 Lafayette St., New York 12, N. Y.*



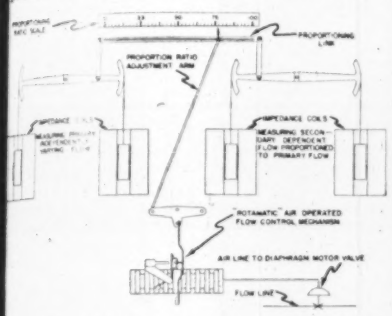
Appliance Tester

New "Model 900" electrical appliance tester (volt-amp-wattmeter) is now built to operate at low range of 0-20 watts as well as high range to 2000 watts. It tests all electrical appliances from bell transformers and clocks to electric ironers and ranges operating on 220-volt three-wire Edison system, locates trouble in a-c. appliances while in actual operation. It is protected from accidental overload by means of a fuse. Overall dimensions are 9½" high, 6¾" wide, 3" deep; weight 8½ lbs., indicating instrument 4" square.—*Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*



Flow Ratio Controller

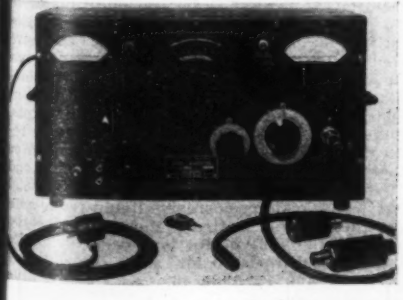
New Flow Ratio Controller is for that class of ratio flow control problems where it is desired to keep one flow at a fixed percentage of a second variable flow. Ratio may be varied at will by a turn of the flow ratio button. Device is said to be "so positive and so simple that what was once a difficult control problem has become easy and reasonable in price." Operation is as follows: Two Rotameters with electric transmissions for remote readings are placed in the respective flow streams. Re-


PROPORTIONING LINK
PROPORTION RATIO ADJUSTMENT ARM
IMPEDANCE COILS
MEASURING SECONDARY DEPENDENT FLOW PROPORTIONED TO PRIMARY FLOW
ROTAMATIC AIR OPERATED FLOW CONTROL MECHANISM
AIR LINE TO DIAPHRAGM MOTOR VALVE
FLOW LINE

mote flow-responsive balance beams from these two Rotameters are placed back to back and connected by a cross beam. From this cross beam is suspended an arm whose position may be changed at will by sliding it on the beam. This suspension arm is connected to a "Rotamatic" 'air-operated control mechanism, which in turn transmits air pressure to an air-operated control mechanism, which in turn transmits air pressure to an air operated valve in the flow line of the stream which is to be maintained at a fixed percentage of the main flow. Thus, position of arm suspended on cross beam determines flow ratio of one stream to the other. The ratio may be readily maintained at any point from 1/5 to one up to as high as 5 to 1 by moving the ratio index button. Liquid flows from 1 g.p.m. up to 6,000 g.p.m. may be proportioned, and gas flows in equivalent volumes. —*Fischer & Porter Company, 923 County Line Road, Hatboro, Penna.*

Signal Generators

New "Type 804-CS1" and "804-CS2 U.H.F." Signal Generators are laboratory type signal generators, capable of producing a range from 7.6 to 330 Mc; frequency calibration accurate to ±2%; and this voltage output is controlled by an accurately calibrated attenuator network which allows control from 1 microvolt to 20,000 microvolts. This output is arranged so that an internal source of modulation at a frequency of 1,000 cycles may be used, or, by use of an incorporated switching arrangement, external sources of modulation may be used between 30 cycles and 20,000 cycles, adjustable from 0 to 60%, indicated by a direct-reading modulation meter. A special input circuit is also incorporated so that, by a circuit-switching device incorporated in panel control assembly, it is possible to modulate the generator from an external source, with a pulse modulation having steep wave fronts and extending in rapidity to pulses of about 20 microseconds. Stray field leakage is held to a minimum by improved



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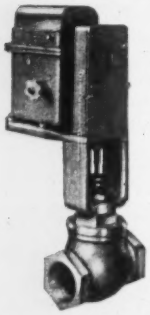

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runs completely through center of barrel. Tip can be extended 3½" to reach out-of-the-way places.

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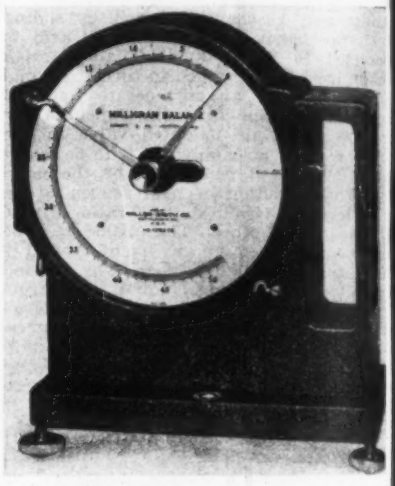
shielding and r-f. filters. A stabilized power supply incorporated in the unit for operation at either 115 volts or 230 volts a.c. 40 to 60 cycles, single-phase, is said to insure an absolute minimum of frequency change due to power line fluctuations. Instrument is enclosed in walnut cabinet with black crackle metal panel, weighs less than 35 lbs., and comes provided with a special 3-foot coaxial output cable of 75-ohm impedance, a fixed 10:1 attenuation reduction unit, a special terminal unit, an adapter plug, line cord, extra blank plug-in coil form, spare pilot lamps, fuses, one set of operating tubes installed as standard equipment.—*Federal Mfg. & Engineering Corp., 211 Steuben St., Brooklyn 6, N. Y.*

Precision Balances

New improvements in R-S single- and double-hook precision balances meet wartime need for fast industrial weighing of large numbers of uniform loads in milligrams, grams or grains, speed up weighing of small quantities of granular materials such as precious ores, stones and powders, liquids, etc. Incorporation of a magnetic damper brings balance to rest quickly without affecting accuracy. Another feature is simplification of readings by use of anti-parallax pointer and hand-drawn scale in place of vernier pointer and printed scale

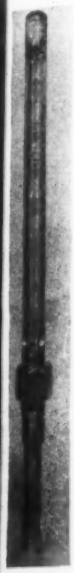


with mirror. These new R-S balances have guaranteed accuracy of 0.2% to 1% of full-scale value, can be furnished in a wide selection of scale ranges from 0-3 mg. to 0-2000 mg., 0-3 to 0-50 grams and 0-10 to 0-1000 grains. Operation of the R-S precision balance is extremely simple: with weighing beam loaded, index pointer is rotated until beam is lifted and the parallax pointer indicates zero. Index pointer then indicates, on dial, weight of material. Reading is obtained directly from dial in milligrams or other units for which balance is calibrated.—*Roller-Smith Co., Bethlehem, Pa.*

Plug Cock Grease

New Dow Corning Plug Cock Grease is a Silicone material having a vaseline-like consistency for use as a grease in lubricated plug cocks and other valves requiring lubrication. It is said to be especially valuable in plug cocks which must operate at elevated temperatures or handle corrosive chemicals. Properties which are said to make it an outstanding material for lubrication of plug cocks are retention of consistency, resistance to corrosive chemicals, non-volatility and thermal stability. It remains a soft grease and will not harden or melt at temperatures between −40°F. and 400°F. It minimizes corrosion of metal valves by keeping corrosive liquid from coming into contact with the metal and thereby allows the valve to operate freely. Its vapor pressure is so low as to be negligible even at 400°F. This insures that volatile

material from the lubricant will not contaminate the product being transported in the line. It is inert, has no corrosive action on metals and does not swell or deteriorate rubber, synthetic rubber or plastics. Its consistency makes it suitable for pressure gun application. It is recommended for temperatures from −40°F. to 400°F. and valves will operate freely throughout this temperature range. (Tests being run on plug cocks in the product lines of hydrocarbon cracking plants indicate that much higher operating temperatures are possible in lubricated valves for this service.) "Dow Corning Stopcock Grease": A silicone material suitable for the lubrication of glass and ceramic stopcocks is also available.—*Dow Corning Corp., Midland, Mich.*



Midget Thermometers

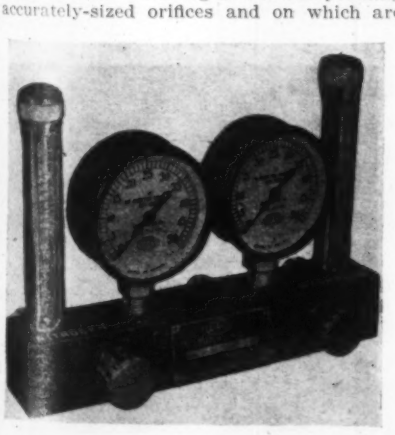
New models of midget thermometers are announced. Previous models are said to have been "installed where temperature indication must be maintained with laboratory accuracy and where large, heavy thermometers are not suitable." New models are said to be ideal for use in distilleries, synthetic rubber industry, petroleum industry, in experimental work especially in the electronic industry and other essential applications. New models are said to be easy to read because of lens-front yellow-back tube and scale engraved on glass. Scale ranges are available from −30 to 700°F. New models are made in both straight and angle types, weighing 5 and 7 ozs. respectively. Straight type, 9" overall.—*H-B Instrument Co., 2525 No. Broad St., Philadelphia 32, Penna.*

Panel-mounted Time-delay Relay

New "Model TD6" time-delay relay is said "to meet the great demand of the electronic industry for the production of transmitter and electronic tubes." It has a cam-operated switch mechanism and is mounted in dust- and moisture-proof Bakelite case for panel mounting. It has a visible index showing open and closed position by means of graduated indicating dial. A totally-enclosed switch unit is used. This switch has definite snap action and positive lock in both operating positions.—*The R. W. Cramer Co., Inc., Centerbrook, Conn.*

Gas Proportioner

New "Airco Gas Proportioner" is said to meet the demands of electron tube manufacturers, heat treaters and others who use mixtures of gases for protective atmospheres. It is designed to produce an accurately proportioned mixture of such gases at a pressure not in excess of 5 lbs./in.². It consists of a mixing block incorporating accurately-sized orifices and on which are



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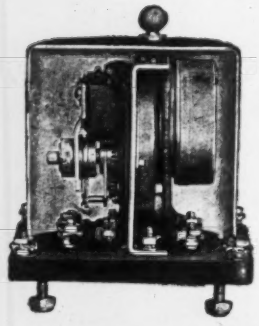

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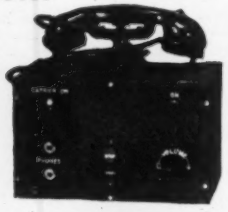

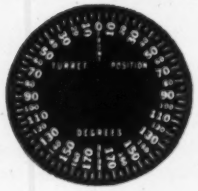

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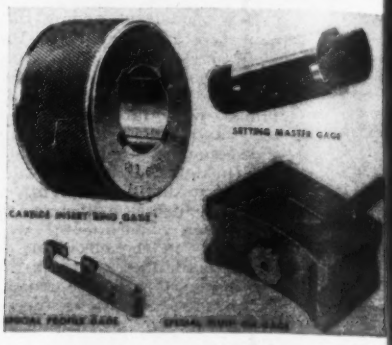
New line of gages to meet standard or special gaging requirements is said to be complete. Plug, ring, flat plug, profile, flush pin, snap, and build-up gages are available



in a full range of standard sizes and tolerances. Standard gages are built to American Gage Design Committee specifications. Special gages are manufactured to purchaser's blueprints. Illustrated are four gages from the complete line. "Crescent" gages are offered in any of three materials: steel, chromium-plate, or carbide, according to demands of particular job. Chromium-plate and carbide are designed for long production runs or for use with highly-abrasive materials. All "Crescent" gages can be held to extremely close limits, while an extra smooth and durable finish is claimed as the result of careful controlled grinding and lapping. Maker states that rigid final inspection and aging by a deep-freeze process are utilized to insure precision.—*Crescent Tool and Die Co., 1469 Electric Ave., Lincoln Park, Mich.*

Specimen Table for Abrasion Tester

New type specimen table for "Taber Abraser" permits testing paper products in moist or wet condition. It holds a sufficient amount of water to cover specimen when performing "wet tests." Wearing action is performed by dual "Calibrase" wheels bearing against specimen under constant pressure, revolving in opposite directions, one sliding radially toward outside, the other sliding toward inside of wear path. Specimen holder travels a complete 360° circle so that differences of grain or weave are revealed. Test results are reported either

numerically as number of "wear cycles" to produce a given amount of wear, or as loss in weight."—*Taber Instrument Corp., North Tonawanda, N. Y.*

Low-pressure Gage

New pressure gage, developed for use in aerodynamic testing and research, is said to be "so sensitive that it will register the pressure exerted by a head of 0.02" of water." It is said to be sensitive to one part in 500 and accurate to one part in 300; and to possess a number of novel features: Backlash is said to have been eliminated, so that action of extremely sensitive series-connected beryllium copper capsules (which serve as pressure-sensitive element) is transmitted to pointer with maximum accuracy. Instrument can be furnished to cover a pressure range as low as 10" of water, and the 330° scale may be calibrated to meet any need. Gages can be constructed with an expanded scale at the lower pressures and a contracted one at higher pressures. A compound instrument measuring both vacuum and pressure is also available. Connections are provided for either ⅛" pipe or ¼" hose. Instrument is mounted in a standard aircraft instrument case 3¼" diam. and 2¼" deep. Static and pressure connections are provided to permit use as a differential gauge.—*Wallace & Tiernan Products, Inc., Belleville, N. J.*

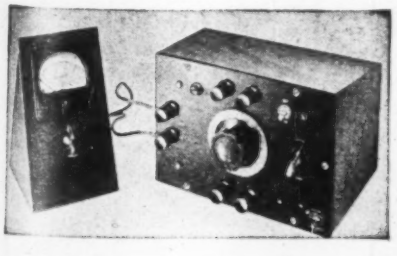
Filament-supply Voltage Regulator

New constant voltage transformer, for built-in automatic voltage regulation of filament supplies, is a small, compact unit in hermetically sealed case. Rated at 6.3 volts,

17 va. output, it will maintain that value within ±1% regardless of line voltage variations as great as ±12 to 15%. It is said to be specially valuable for stabilization of E-C oscillator circuits. Electronic equipment, in which the transformer is a built-in component of the basic design, does not require filament voltmeters or manual controls.—*Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.*

Slide-wire Bridge

New "Type LB Direct-indicating Comparison Bridge" is for speedy testing of resistors, capacitors or inductors in terms of ohmage, microfarads or henries, respec-



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DIMENSIONS: 4¾" wide, 6" high, and 8½" deep.
WEIGHT: Approximately six pounds. **PRICE:** $135.00 f.o.b. Boonton, N. J.

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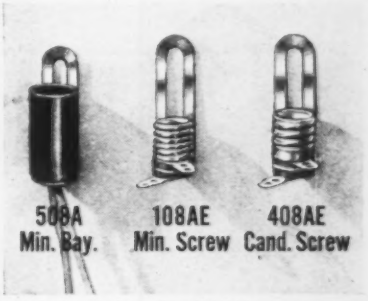

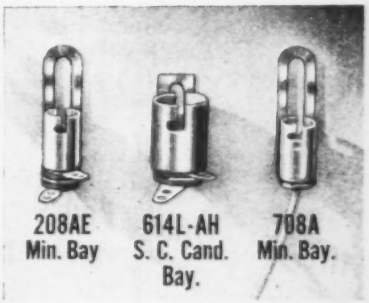

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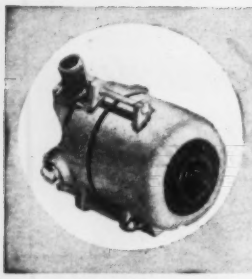

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for important instrument applications

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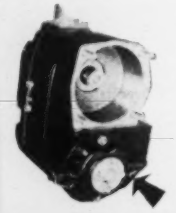

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tively. It is an a-c. slide-wire bridge with vacuum-tube null indicator arranged so that resistors, capacitors or inductors can be compared with a similar standard. Ranges are: Capacitance, between 0.0001 and 1 mfd.; Resistance, between 200 ohms and 20 megohms; Inductance, between 5 and 50,000 henries. Slidewire is uncalibrated; external standards are used. In use, after instrument is set up, parts under test are connected one by one to the "X" terminals and are then rejected or passed by observing indicator deflection. Operator does not rotate dials or press buttons. Limits may be set with any combination of high or low value. Bridge comprises main unit with separate instrument on stand, the former measuring 7" × 8" × 5½". Net weight, 7 lbs.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City, N. J.*

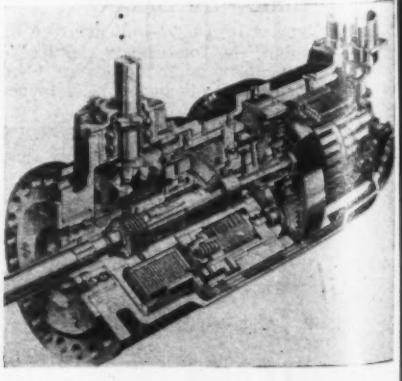
Temperature Control Switch

New "Model VD-2C" is latest addition to maker's line of temperature limit switches; embodies previous model's features plus the following new ones: (1) Water- and vapor-tight sheet-metal cover. (2) Switch adjusting screws have locking screws instead of disks to lock adjustment. (3) Main temperature can be more easily locked in place with a screw driver instead of the usual

wrench. (4) Simplified wiring connections are made through a ½" pipe tapped hole in base. (5) 5-lb. reduction in weight against previous water- and vapor-tight models. This new "Model VD-2C" can be used for any temperatures from —100 to 1400 F. (also to 1800°F.) Photo shows "VD-2C" with cover removed.—*Burling Instrument Co., 253 Springfield Ave., Newark, N. J.*

Electric Servometers with Overload Protection

New "Electric Actuators" were originally designed for applications requiring electric motor-driven gear-reduction units to operate bomb bay doors, wing flaps, etc. are



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Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile, we would welcome the opportunity of working with you in developing your post-war designs.

Remember, Chelsea has been making special movements for recording instruments for many years.

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REGULATED POWER SUPPLY

PROVIDES electronically regulated power supply for general laboratory and production testing. Especially useful to supply moderate amounts of d-c power at 180-300 volts.

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GENERAL ELECTRIC

164-C9

ELECTRONIC MEASURING INSTRUMENTS

NEW POST-WAR PRODUCTS AVAILABLE FOR MANUFACTURE AND DISTRIBUTION UNDER LICENSE

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ELECTRIC MICROMETERS
ELECTRIC THERMOMETERS
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Remote Electrically Indicating, Recording and Controlling.

Operate from commercial voltages and frequencies through a new system of Micro Electrical Measurement.

Providing simple accurate and permanently dependable performance.

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Correspondence Invited from Manufacturers Interested in Post-war Manufacture and Distribution.

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A dependable direct-reading instrument for determining the Q or the ratio of reactance to resistance, of coils. Used in design and production engineering of Radio and Electronic equipment. Condensers and other components readily measurable.

Determines effective inductance or capacitance

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INDISPENSABLE TO MANUFACTURERS

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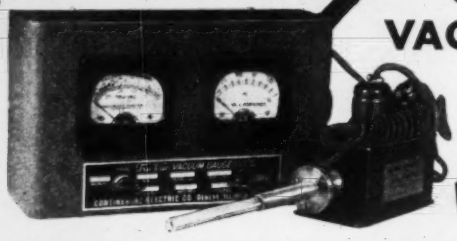

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VACUUM GAUGE
(Pirani Type)
For Accurate High Vacuum Measurement

OUTSTANDING ADVANTAGES IMPORTANT TO YOU!

1. Gives instantaneous and continuous reading.
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4. Indicates vacuum changes as they occur.
5. Adaptable to any high vacuum pump or system.
6. Easily placed on any point on vacuum system.

These D. C. operated gauges require only one or two No. 6 dry cells and may be installed in rubber, sealed to hard or soft glass systems or coupled to ⅛ inch standard pipe connection. Write for more complete information, description of models and prices.

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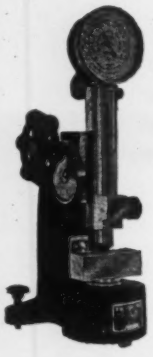
done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 36 years.



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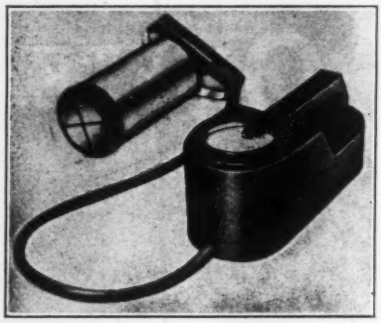

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of lumber checked in THREE SECONDS

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Calibrated with a direct percentage reading dial, with a range from zero to 25 per cent. Completely portable and self-contained. Anyone can operate it.

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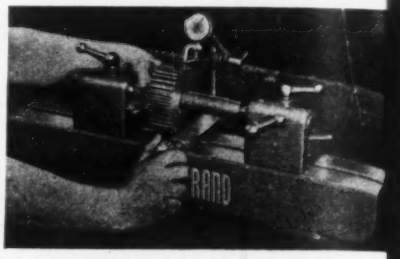
capable of numerous other functions, a available in concentric and right-angle d sign to provide maximum compactness a clearance, depending on characteristics application. Design features include an a tomatic compensating torque limiting devi in the form of a multiple-disk clutch whi protects reduction gearing and motor event of undue loading. Specially-design magnetic equalizing clutch prevents one running and jamming. This feature al facilitates hand operation on models equipped by eliminating resistance of se train and motor. Explosion-proof motor available in certain models are complete enclosed against explosive vapors, as w as mud and dirt. Motors are available f 24-volt d-c. operation. Illustrated is "Electric Actuator" which has a clutch se ting of 125 lb.-ft. Others are available meet specific requirements.—*Eclipse-Pione Div., Bendix Aviation Corp., Teterboro, N*

Bench Centers

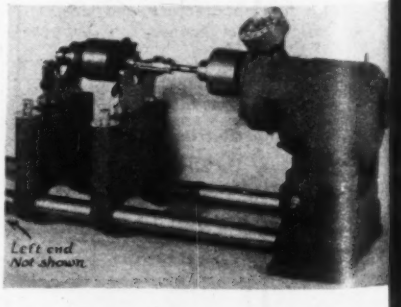
New Bench Center makes it possible maintain accuracy to within limits of 0.00 in checking for runout. Precision checki of work between centers is said to be si plified and speeded by "one-handed contr over all movable elements, which leaves o erator's other hand free to control part b ing checked. Unclamping, positioning a locking in place of both L.H. and R. heads are easily achieved with a sing hand operating top lever. Indicator suppo is manipulated with one hand when movin it away from work for loading and unloa



ing and against work when checking f runout. Center holes of R.H. and L.H. head are bored together for accurate alignmen Heavy ribbed base prevents deflection whe clamping and unclamping. Bench Center in cludes bed and two heads as standard equip ment and is available in following sizes 6" × 18", 6" × 36" 12" × 36", 12" × 48 12" × 60", and 12" × 72". Dial indicato with adjustable holder is available as extr equipment.—*Sundstrand Machine Tool Co Rockford, Ill.*

Simplified Dynamic Balancer

New "Globe Service Dynamic Balancer has been developed especially for repa shops and maintenance organizations wh may have a few parts to balance, but no sufficient quantities to justify purchase o an elaborate balancer. Range of weight and sizes which can be accommodated b this model: up to 300 lbs. weight and 20 diameter. Parts can be balanced until the remaining vibration is less than 0.0002"—*Globe Tool & Engineering Company, 1 Davis Ave., Dayton, Ohio.*



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SENSITIVITY RESISTANCE
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Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

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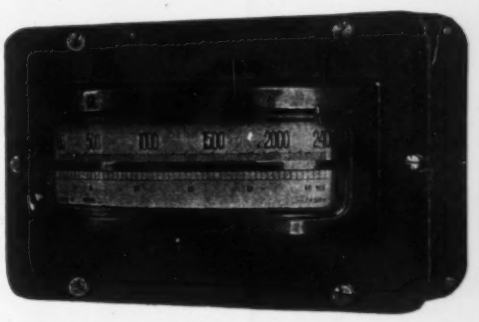

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New Products with good prospect for the post war market wanted by well established East Coast manufacturer. Full facilities for development work available.

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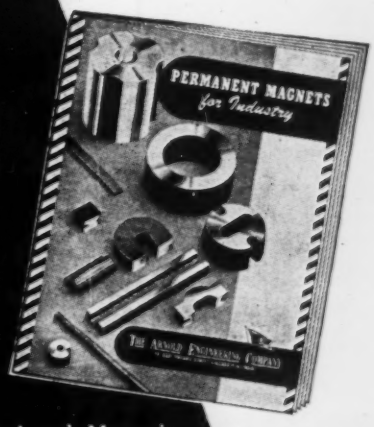
New!

PERMANENT MAGNETS MANUAL



From many years experience in the production of ALNICO permanent magnets, The Arnold Engineering Company has prepared an authoritative, up-to-date manual of valuable information on the design, production and application of the modern permanent magnet.

Contents include such subjects as Magnet Materials, Resistance Comparisons, Physical and Magnetic Properties, Demagnetization and Energy Curves, Fabrication, Design and Testing. Charts and tables illustrate and explain various aspects of the discussion.

Recent improvements have opened many new fields for permanent magnets to reduce the cost and improve the efficiency of many devices.

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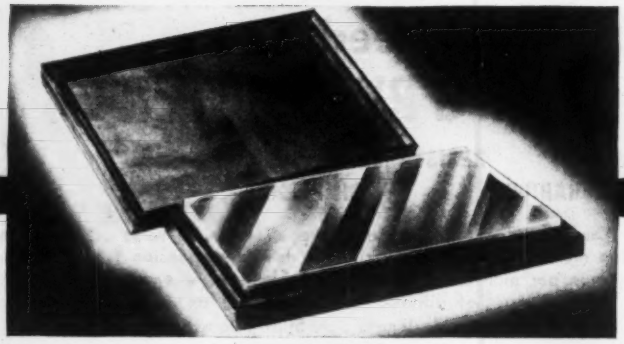
147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS
Specialists in the Manufacture of ALNICO PERMANENT MAGNETS



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"Instrumentation Comes of Age"
(Continued from page 578)

theory of matter; Electron movement during current flow through metal conductors; Emission of electrons and their controlled flow through vacuum and gases.

Part II—Theory of current rectification by vacuum tubes; Kenotrons—high-voltage, low-current rectifiers.

Part III—How gas in a tube neutralizes space charge; Gaseous rectifier tubes.

Part IV—Electronic amplification.

Part V—Electronic generation of high-frequency alternating currents.

Part VI—Electronic oscillators for radio and carrier current transmission.

Part VII—Basic circuits for electronic control.

Part VIII—Industrial applications of electronic regulation.

Part IX—Industrial applications of electronic control.

Part X—Electronic conversion of light into electricity—and electricity into light.

* * *

Measurement and Control Featured at AIEE Meeting

Numerous technical papers of interest to instrument men were presented at the Los Angeles Technical Meeting of the AIEE, Aug. 29-Sept. 1. The following is a list of only those of which the Society sent copies to the Editor of *Instruments*. Prices are given for the convenience of readers desiring to order them from the AIEE, 33 West 39th St., New York 18, N.Y.

Electrical Control in Automatic Pilots, C. M. Young, E. E. Lynch, and E. R. Boynton, General Elec. Co. 20 cents.

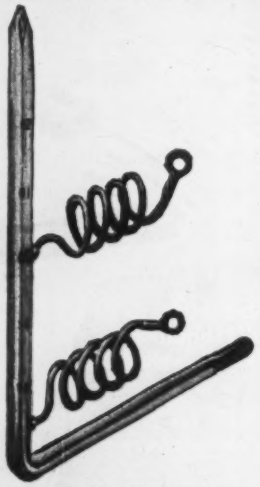
Application of Electronics to Aircraft Flight Control. W. H. Gille and R. J. Kutzler, Minneapolis - Honeywell Regulator Co. 15 cents.

Electric Automatic Pilots for Aircraft. P.

(Continued on page 588)

For Extremely Close Temperature Control

Visual-Stats



● Sensitivity of a hundredth of a degree is easily attainable. ● Top of mercury column visible at control point (where most important) because electrodes terminate at back of tube. No encircling metal bands! ● Available in angle form (illustrated) or conventional straight form. ● Send for brief, attractive bulletin.

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Oldest Thermometer Manufacturer in Philadelphia

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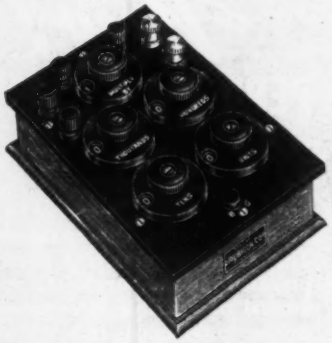

Rubicon Wheatstone and Kelvin Bridges are available in a number of types to suit various applications. All are made in accordance with the highest traditions of the instrument maker's art and are fully guaranteed.

Described in Bulletin 100 which also lists National Bureau of Standards and other standards of resistance.

Copies available on request.

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Electrical Instrument Makers
Ridge Ave. at 35th St. Philadelphia 32, Pa.

A STRONGER FACTOR in TODAY'S NEW
COMPLETE CIRCUIT PROTECTION

EXTRACTOR POSTS
WITH ELECTRICALLY WELDED SIDE TERMINALS

Terminals integral with inner shell mean more strength against extreme shock, vibration and temperatures. Maximum electrical conductivity. New construction for convenience and durability. Shock-proof visual inspection. Specially designed grip prevents fuse from dropping out.

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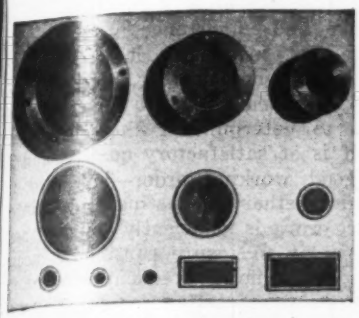

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(Barrier-Layer Type)

of highest sensitivity

- Great variety of sizes and shapes
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- Full cooperation regarding application and circuits

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SAVE TIME AND MONEY!

By using PYRO, a self-contained, DIRECT READING, sturdy unit made to stand rough use. It is absolutely accurate and dependable, and quickly pays for itself.

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLERANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

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Plant & Lab.

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2. **In unusual sizes**—one order recently called for 300 scales 1/4" wide by 84" long; another for scales 32" wide by 66" long.

Whatever your requirements, write us. The uniform accuracy of Maymer scales, reasonable price, and speed of shipment will please you.

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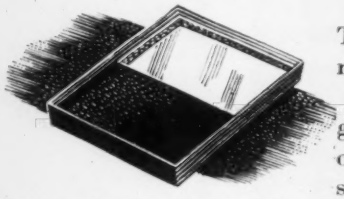


The U.S. Navy uses sextant mirrors in large quantities. Merely a square inch of glass, silvered over a part of one surface—but made so precisely that if a ray of light strikes it, the reflected rays from the front and rear surfaces will diverge considerably less than two inches in a distance of a mile. Such accuracy, immeasurable by any mechanical instrument, is essential for the safe navigation of our ships.

Kollmorgen, leading producer of sextant mirrors, makes many other optical and mechanical devices to similar standards of precision. If your postwar products or ideas embrace close tolerances in glass or metal, consult Kollmorgen . . . now!

KOLLMORGEN OPTICAL CORP.

2 Franklin Avenue Brooklyn, N. Y.

TESTING PROCEDURES

(Continued from page 581)

nature and importance of the equipment—not just when it is suspected that it has gone haywire. From the records of *periodic* tests, it is possible not only to determine if the instrument itself is of satisfactory quality, and is in good working order—but also to judge whether the testing and maintenance work is sufficiently frequent and competent to insure continuous accuracy, and is not so frequent or overdone as to be time-wasting.

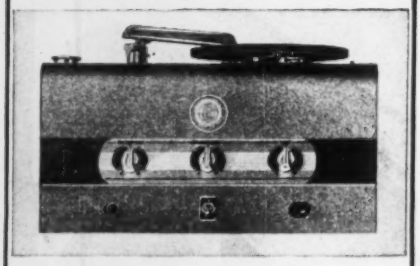
SUMMARY

One feature in each of the three major fields of industrial testing has been briefly discussed:

(1) the possibility of bargain-hunting for odd lots of *raw materials*;
(2) the use of combination testing and control devices in *operations*;
(3) the desirability of using fixed intervals in *equipment testing*.

Now to correlate this discussion with the basic purpose of this conference. It should be possible to attain increased production per unit of equipment and manpower, as well as increased production per ton of material or per dollar, through increased use of *evaluative testing of materials*, together with the *control testing or directive testing of operations* that is made possible by new devices, the latter being insured by proper application of equipment testing and maintenance.

20-WATT UNIVERSAL AMPLIFIER



Plug in for A.C. or 6-volt auto battery; no power pack necessary. Uses mike and built-in phono at same time. 78 RPM motor, 9-inch turntable, crystal pick-up, separate on-off switch. Long-playing needle included. Continuously variable tone control on inclined eye-level control panel. Use one or two 8-ohm speakers without need of extra transformer. Has one 6SJ7GT, one 6SC7, two 6L6Gs in push-pull, two 6X5GTs.

Model 6720, with tubes, F.O.B. New York **$56.28**

Model 6721, same as 6720, less phono player **$42.87**

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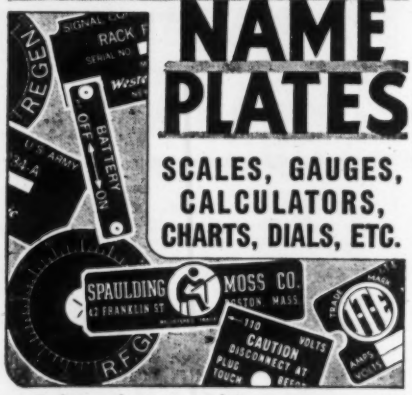
PLASTIC NAME PLATES



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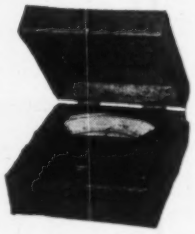

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SIMPLEST AND MOST EFFICIENT

Bulletin 504

THREE DIFFERENT STYLES

Portable Standard with single electrical zero return.

Two Button Pointer Shift in place of our patented standard zero return at a lesser cost.

Acknowledged leaders in development of high sensitivity meters

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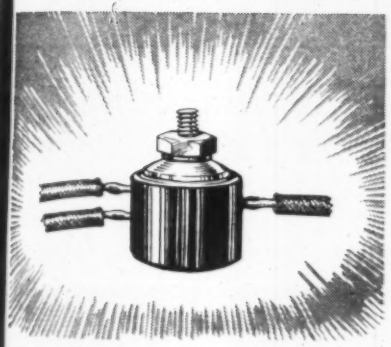

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★ Insulated metal core supports resistance winding. Element imbedded in cold-setting inorganic cement. Maximum heat conduction and radiation.

★ Normal current rating may be exceeded by 50% at any setting up to 1/3 total rotation, without damage.

★ Rotor design provides smooth rotation and positive conduction at all settings.

★ Exceptionally rugged, electrically and mechanically.

★ 25- and 50-watt ratings. Enclosed type here shown. Also in non-enclosed type.

★ Hundreds of thousands of these Clarostat power rheostats are now in daily use. Especially so in aircraft assemblies. Indeed, they are standard equipment in planes, radio, electronic and industrial equipment. They are proving that "They can take it"—and then some.

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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	Roger W. Allen, 376 Nelson St., S.W., Atlanta	Sept. 25[B]	Ellen Rice Tea Room	(to be announced)	C. D. Schm... Engr., Plantation Pi... Line Co.
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	Sept. 15[C]	Park Plaza Hotel	Mfre. of plastics	Dr. R. K. W... J.H.U.
Chicago	Chicago Society for Measurement & Control	A. J. Butler, 2626 W. 31st Blvd., Chicago	Sept. 11[B]	Merchants' & Mfrs' Club, 237 M. Mart	Strain Gages and their Applications	C. H. Gibbe... Baldwin-Sou... Park
			Oct. 2[D]		(to be announced)	(to be anno...
Cleveland	Cleveland Instrumentation Society	W. A. Stubblefield, 2085 W. 104th St., Cleveland 2				
Fort Worth	Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth, Tex.	Sept. 21[A]	Texas Hotel	Electronic Voltmeters	H. F. Farrin... Texas Elec. Service
			Oct. 19[A]	Texas Hotel	Model Airplane Control	C. E. Osborn... Jr., Consol-Vult... Aircraft Co.
Gulf Coast	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Tex.				
Hartford	Hartford Society for Measurement & Control	S. J. Zelle, Whitney Chain & Mfg. Co., Box 1410, Hartford, Conn.				
Kansas City	KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.	Sept. 26[D]	Bluebird Cafeteria	"Electronics Today"	Westinghouse Speaker
			Oct. 31[B]	Bluebird Cafeteria	The Rotameter and Its Secrets	Kermit Fischer, Pres. Fischer & Porter Co.
Newark	New Jersey Society for Measurement & Control	Robert H. Gray, 1 Whippoorwill Way, Mountainside, N. J.	Oct. 3[B]	Essex House	Appl. of Electronics to instruments	C. P. Bernhard... Westinghouse E... & M. Co.
			Nov. 14[B]	(N. Y. City—joint meeting)	Pyrometry in Steel Industry	Dr. R. B. Sosman, U. S. Steel Corp.
New York	New York Society for Measurement & Control	H. R. Kalbfleisch, 144-35 No. Blvd., Flushing, N. Y.	Sept. 26[B]	Men's Faculty Club Columbia Univ.	Variable-orifice Flowmeters	Kermit Fischer, Pres. Fischer & Porter Co.
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Illinois	Sept. 22[B]	Vogel Rest't, 1250 Indianapolis Blvd., Hammond, Ind.	Some Forgotten Fundamentals of Instrumentation	M. F. Behar, Editor, *Instruments*
Philadelphia	Philadelphia Society for Instrumentation	J. E. Gambrill, 1317 Spruce St.	Sept. 20[B]	Engineers Club	Inter-connected Instruments	J. A. Pellettere, Gulf Oil Corp.
			Oct. 18[B]	Engineers Club	Combustion Control	M. J. Boho, Hagan Corp.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.	Sept. 25[B]	Roosevelt Hotel	Instruments and Synthetic Rubber	J. G. Kirkpatrick, Koppers United Co.
			Oct. 23[B]	Roosevelt Hotel	Flow Measurement Eng'g	L. K. Spink, Foxboro Co.
St. Louis	St Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto				
Washington	Instruments Society of Washington	W. A. Wildhack, 328 N. Oxford St., Arlington, Va.	Sept. 26[D]	Interior Dep't Auditorium	(to be announced)	(to be announced)
Wyandotte	Instrument Society of Wayne County	John MacPherson, RFD No. 1, Wyandotte, Mich.	Sept. 25[B]	Presbyterian Church Hall	Process Instruments and Control	Ralph Cowan, Bailey Meter Co.

[A]Meeting at 7:30, no dinner. [B]Dinner at 6:30, meeting at 8. [C]Dinner at 7, meeting at 8. [D]Meeting at 8, no dinner.

KANSAS CITY

The weatherman finally delivered our cooler weather which resulted in a very nice turn-out for our August 29 meeting at the Bluebird Cafeteria.

Roy Carns of the Sinclair Refining Co., Kansas City, Kansas, presented a basic lecture on low-pressure manometers.

Our Quiz Kids (Lou Mears of Sullivan-Mears, R. R. Cox of Phillips Petroleum, H. R. Hoyt of Great Lakes Pipe Line and Leo Burnett of Hercules Powder) handled some real tough ones. The question of how to get the bubble in the manometer sort of stumped them. Perhaps our technical committee may come up with the answer at the next meeting.

Paul Elfers, Sales Manager of Fisher Governor Co., Marshalltown, Iowa, presented an illustrated lecture on "History and Development of Liquid Level Controllers." Even old-timers learned something new.

One of the members remarked, "I consider that the information I have gained from these meetings is worth another $10.00 in my pocket." Since our annual dues are only $5.00 (due October 1) it leads us to believe that our members and guests are really making money when they attend the meetings. —W. A. REICHOW

PITTSBURGH

A visit to Mexico City showing some of the lovely residences and flower gardens, the Floating Gardens of Xochimilco, the Pyramids, sailfishing at Acapulo, then we will pass through Cuernavaca, Taxco, Cholula, Puebla, Orizaba, and Fortin de la Flores. We will also attend a championship bull fight. A special side trip will take us to the new volcano of Paracutin by way of the lovely fishing Lake Patzcuaro.

This special trip will be conducted by Phil Sprague, president of the Hays Corporation, after the regular lecture on Sept. 25. These colored movies were taken by him on his recent trip. —R. RIMBACH

WASHINGTON

After the September meeting, all meetings will be held on the THIRD Tuesday of each month, in the Interior Department Auditorium, unless otherwise announced.

—W. A. WILDHACK

"Instrumentation Comes of Age"

(Continued from page 584)

Halpert and O. E. Esval, Sperry Gyroscope Co., Inc. 20 cents.

Influence of Electricity on Aircraft Instrumentation. C. F. Savage, General Elec. Co. 15 cents.

Instrumentation of 400-Cycle Aircraft Electrical Systems. A. J. Corson, A. G. Stimson, and W. A. Soley, General Elec. Co. 20 cents.

The Gyrosyn Compass. O. E. Esval, Sperry Gyroscope Co., 15 cents.

Carbon-Pile Voltage Regulators for Aircraft. W. G. Neild, Bendix Aviation Corp. 15 cents.

Considerations in Servomechanism Design. S. W. Herwald, Westinghouse Elec. & Mfg. Co. 25 cents.

Electric Gun Turrets for Aircraft. J. D. Thompson. General Elec. Co. 15 cents.

* * *

ASM to Feature Instruments for Quality Control

At the 26th annual Metal Congress, Cleveland, Oct. 16-21, emphasis will be placed on instruments for the control of quality. No less than four complete panels during convention week will discuss as many phases of the general topic: Measurement of Linear Dimensions, Tuesday, 4 p.m. Means to Establish Identity, Wednesday, 4 p.m. Detection and Measurement of Internal Defects, Wednesday, 8:30 p.m. Atmosphere and Combustion, Friday, 4 p.m.

These unique discussions will devote a major share of attention, not to the tried and true equipment promoted commercially for so many years—although these will be given an appropriate hearing—but more especially to specialized instruments developed in this, that or the other plant for easy and accurate measurement.—E. E. THUM, Editor, *Metal Progress*.

* * *

National Electronics Conference

Among the instrumentation papers to be presented at the National Electronics Conference, Medinah Club, Chicago, Oct. 5-7 are the following:

The Electroencephalograph and Its Applications, by Professor R. W. Gerard.

Electrocardiography in Physiology and Medicine, by Dr. Louis N. Katz.

Electronic A-c. Power Regulators, by R... F. Wild and L. B. Cherry.

Aircraft Electronic Applications, by A. P... Upton.

Industrial Fluoroscopy of Light Materials, by Scott W. Smith.

Field Emission Applied to Ultra-speed X-ray Technique, by C. M. Slack.

A Method for the Generation of Quasi-continuous Frequency Spectra, by Harold Goldberg and Richard G. Talpey.

Mass Spectrometer and Its Applications, by Dr. J. A. Hipple.

Electronic Mechanisms in Plant and Laboratory, by Dr. T. A. Cohen.

Electronic Measurements in Industrial Processes, by H. D. Middel.

Design Factors in Application of Relays to Electronic Circuits, by R. H. Herrick.

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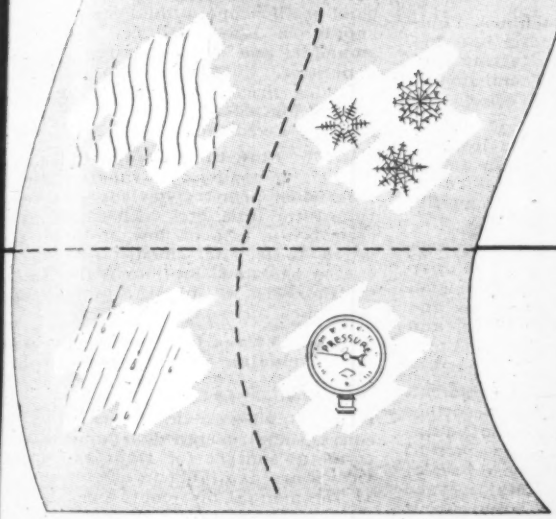

With the rapidly growing understanding of the advantages of chamber-testing of instruments, the question of testing facilities is becoming more serious.

Laboratories of leading technical schools and Government departments will often, as a help-win-the-war move, accept chamber-testing work. In the main, though, they prefer to devote their facilities to research . . . and understandably so.

There are still more important reasons why, instead of "farming out" their testing, instrument manufacturers benefit by having testing chambers in their own laboratories. It saves valuable time. It assures facilities for emergency jobs. It increases output. It is economical.

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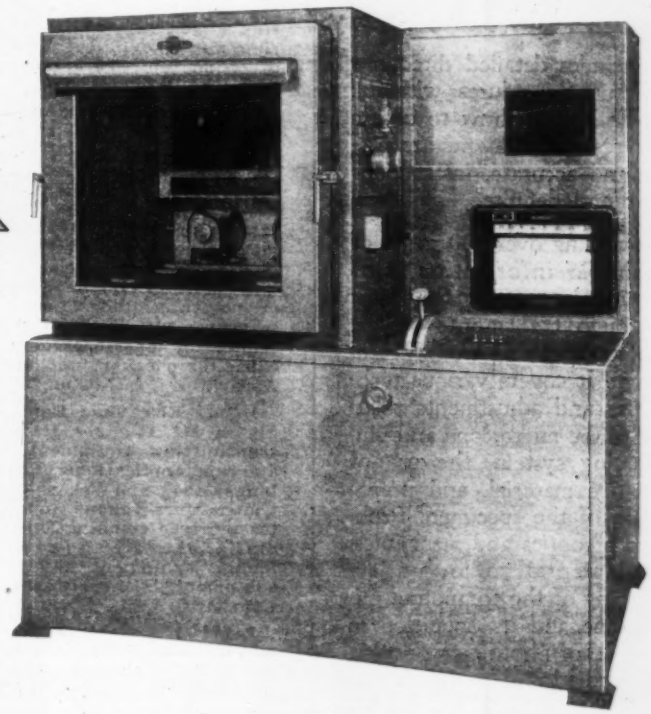

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

L-157 **Microfilming.** Folder, 7″ × 9″, 4 pages, discusses advantages of microfilming drawings, records, letters, etc. Microcopy, 2800 West Olive Ave., Burbank, Calif.

L-158 **Hydraulic Test Machines.** Folder, 8½″ × 11″, 4 pages, describes hydraulic test machines for testing hydraulic systems and their components. Greer Hydraulics, Inc., 39 West 60 St., New York 23, N. Y.

L-159 **Thermoregulator.** Form 759, 3½″ × 6″, 8 pages, entitled "97 Men Didn't Die," describes the new H-B SS-5 relay. H-B Instrument Co., 2500 N. Broad St., Philadelphia 32, Pa.

L-160 **Gages.** Loose-leaf folder, 8½″ × 11″, 35 pages, covers: roll thread snap gages, threaded plug gages, precision ring gages, pipe thread plug gages and ring gages, cylindrical plug gages, and precision taps. Vard, Inc., 2961 E. Colorado St., Pasadena 8, Calif.

L-161 **Special Electronic Equipment.** Bulletin, 8½″ × 11″, 12 pages, describes and illustrates special electronic equipment such as a high-voltage low-current power supply for general-purpose breakdown tests up to 10,000 volts; a tube tester for static, dynamic, and output measurements for either section of a dual tube; a tube checker for measuring emission and shorts in initial tests of power pentodes; a tube tester for measurement of characteristics on the family of super-control r-f pentodes; a capacitor checker; and others. Technical Apparatus Co., Boston 20, Mass.

L-162 **Electronic Equipment.** Catalog, 8½″ × 11″, 16 pages. Radio receiving and transmitting equipment for land, sea, and air applications. Specifications for long-wave and short-wave receivers, transmitters (phone and CW), transmitter-receiver combinations, and antennas. Similar data are also given for direction-finding equipment and transmitter test equipment. Fisher Research Laboratory, Palo Alto, Calif.

L-163 **Electronic Tubes.** Catalog, 8½″ × 11″, 28 pages. Dimensions and technical specifications for various types of phototubes and rectifier tubes. Continental Electric Co., Geneva, Ill.

L-164 **Radio All-out for Victory.** Publication, 8½″ × 11″, 32 pages. Reviews the development of radio since its inception, and explains its importance, as well as the importance of other electronic equipment, in current events. Military uses of electronic equipment are touched upon as much as possible without violating national security laws. Numerous photographs and drawings illustrate the text. Radio Corp. of America, Radio City, New York, N. Y.

L-165 **Portable Instrument Washer.** Bulletin, 8½″ × 11″, 4 pages. Especially designed for washing and cleaning aircraft, tank, automobile, and navigation instrument; also can be used for production cleaning of small delicate parts. Photographs and drawings supplement the text. Naxon Utilities Corp., 2101-11 Walnut Street, Chicago, Ill.

L-166 **Electronic Instruments for Laboratory Use.** Leaflets 177-3503-100; -170; -171; -190; -200, 8½″ × 11″, 2 pages each. Issued as supplements to publication No. 177-3503, these publications provide specifications and descriptive data on a wide-band oscilloscope; a dual regulated power supply; a low-impedance thermocouple ammeter; and a visual-alignment signal generator. Publication No. 177-3505-20 provides price lists and ordering information on each of the above. General Electric Co., Schenectady, N. Y.

L-167 **Flow Instruments.** Bulletin, 8½ × 11″, 16 pages. Flowmeter operation from such primary devices as a Venturi tube Pitot tube, etc., which indicates and records the rate of flow on evenly-graduated scale and chart, and also integrates the flow. Simplex Valve and Meter Co., 68th & Upland Sts., Philadelphia 42, Pa.

L-168 **Valves for Hard-to-handle Liquids, including Solid Suspensions.** Bulletin 1455, 8½″ × 11″, 8 pages, describes a new type of valve in which a diaphragm-and-weir arrangement replaces conventional design depending on metal-to-metal contact for tight shut-off. New valves are available in sizes from ½″ to 8″, for manual or remote operation, with linings of rubber, glass or lead where required. For many difficult services, new valves are the only ones found satisfactory. McAlear Mfg. Co., 1901 S. Western Ave., Chicago 8, Ill.

L-169 **"Highways of the Air."** Booklet, 6″ × 9″, 16 pages. An elementary explanation of radio navigation aids and airport traffic control equipment. Describes radio range transmitters, position markers, cone-of-silence marker, fan marker, inner and outer spot markers, and radio equipment for airport traffic control. Radio Receptor Co., Inc., 251 West 19th St., New York 11, N. Y.

L-170 **Modern pH and Chlorine Control.** Book, sixth edition, 5″ × 7½″, 8 pages. In addition to listing and providing specifications for many types of comparators for colorimetric measurement of pH, this publication explains the meaning of pH and its importance in the control of industrial processes, contains a theoretical treatment of pH measurement, buffer action, the electrometric and colorimetric methods of measurement, etc. In addition to comparators for general applications, there are also kits available for specific applications such as phosphate comparators, boiler water comparators, swimming pool sets, water analyzers, and many others. All units are priced and illustrated. W. A. Taylor & Co., 7300 York Road, Baltimore 4, Md.

L-171 **"The Laboratory."** Vol. 14, No. 6, 6″ × 9″, 24 pages. Features an article on tungsten production and its importance. Other articles cover (1) new culture medium for the laboratory preparation of Penicillin, (2) small chemically inert particles to give gentle and safe boiling in test tubes and distillation flasks, and (3) a simple means of testing boiler feed water. Eimer and Amend, 635 Greenwich St., New York, N. Y., and Fisher Scientific Co., 717 Forbes St., Pittsburgh, Pa.

L-172 **Engineering Equipment and Service.** Catalog, 8½" × 11", 64 pages. Specifications of equipment for the metals industries, this publication lists such materials and apparatus as thermocouple wire, leads, and protecting tubes; various types of thermocouples and accessories; circular and strip charts for recording instruments; pyrometers, pressure and vacuum gauges; standard verifying load rings, Brinell Hardness testers, laboratory furnaces, and many others. Facilities for service work are illustrated. Claud S. Gordon Co., 3000 S. Wallace St., Chicago, Ill.

L-173 **Aircraft Landing-gear-and Flap-position-indicating Equipment.** Bulletin GET-1172, 8½" × 11", 20 pages. An explanation of the theory and operation of the A-N, two coil and the two wire, two-coil, a-c Selsyn systems. Text is illustrated by schematic diagrams and drawings. In cutaway views colors are used to assist the reader in easily distinguishing the various circuits. This publication is a supplement to wall charts GEL-760A, GEL-761A, GEL-769, and GEL-770. General Electric Co., Schenectady, N. Y.

L-174 **Combustion Instruments and Control.** Bulletin 44-687, 8½" × 11", 12 pages. A condensed catalog. Hays Corp., Michigan City, Ind.

L-175 **Aircraft Liquid-level-indicating Equipment.** Publication GET-1185, 8½" × 11", 24 pages. Theory and operation of a-c Selsyn systems with schematic drawings and photographs. Publication is a supplement to wall charts GEL-746A, GEL-776A, GEL-864, GEL-865, and GEL-866. General Electric Co., Schenectady, N. Y.

L-176 **Combustion Control for Boiler Furnaces.** Catalog N-O1M-163, 8½" × 11", 8 pages. Pertains to automatic combustion control equipment, and includes numerous photographs to illustrate features of the apparatus and to describe particular applications in various industries. Covers not only complete systems but also the principal components. This information should be of interest to anyone connected with central stations or large industrial power plants. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

L-177 **"Vision Unlimited."** Publication, 8½" × 11", 14 pages. Reviews the growth of Air Express Service since its inception in 1910 when a package containing $1,000 worth of silk was flown from Dayton to Columbus, Ohio., in a Wright biplane and the pilot's course, for part of the distance, was marked by a white streamer trailing from the back of a plain. Since that time Air Express routes have extended to all parts of the world. Text is illustrated by photographs, drawings, and charts. Air Express Div. of Railway Express Agency, Inc., 230 Park Ave., New York 17, N. Y.

L-178 **Relays and Timers.** Catalog F, 5th Edition, 8½" × 11", 48 pages. Electrical specifications and engineering data on relays and accessory parts. Covers sensitive and power relays, overload relays, sequence or stepping relays, differential relays, etc. Includes specifications for coils, metal housings, and glass covers. Numerous drawings and photographs are included. Struthers Dunn, Inc., 1321 Arch St., Philadelphia, Pa.

L-179 **Electrical Instruments for Communications.** Bulletin B-3283, 8½" × 11", 8 pages. Provides data on electrical indicating instruments and recorders. Covers a variety of panel, switchboard, and portable indicating instruments as well as recording instruments and accessories. Outline and drilling plans, and photographs, illustrate text and supplement the technical data. Several pages explain the basic principles that must be considered when selecting instruments for particular applications. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

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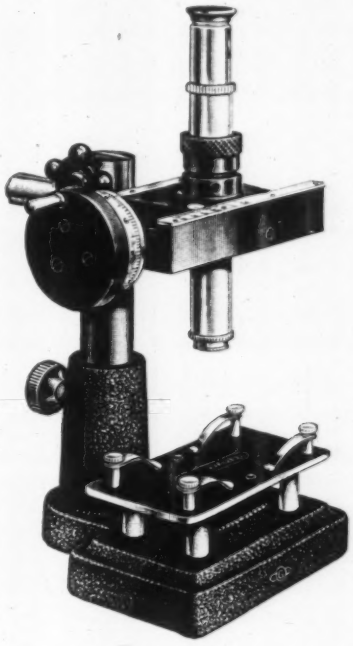

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